THE HISTORICAL AND ARCHAEOLOGICAL ANALYSIS

OF THE SWORDS OF *LA BELLE*

A Dissertation

by

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ABSTRACT

This research involves the conservation, historical and archaeological analysis of a cache of swords recovered from the 17th-century French shipwreck *La Belle*. The central premise of my research model is the incorporation of the theories and methodologies of several convergent disciplines; concentrating on the material and cultural aspect of these weapons, and the technical processes involved with their conservation. The integration of the conservation process and research results with the archaeological evidence, both objects and context, can lead to new methods of archaeological inquiry. The details of materials composition and structure, sequence of processing, properties, performance, or use should define the way modern material culture research is conducted.

This research approach seeks to answer such relevant questions as what is the past and current history of the sword types recovered from *La Belle*? What materials, technology or skilled craft aided in the production of these swords and their individual components? What was the practical and symbolic function of these edged weapons? Subsequently, the data lead to interpretations of the finds and their broader meaning within the context of the shipwreck itself. I am convinced that the research presented in this dissertation will help to facilitate a wider dialogue about swords and other edged weapons among weapons historians and archaeologists.

The conservator is dedicated to maintaining the long-term preservation of cultural artifacts through examination, documentation, treatment, and preventive care and research. Conservation is an interdisciplinary field involving knowledge and skills acquired from a number of diverse disciplines in the arts and sciences. As a result, conservators must have a working knowledge of materials technology, chemistry, biology, physics, art history, and archaeology.

The results of the case studies discussed in chapter six, though limited in scope, proved most promising, indicating that there are always viable alternatives to the methods and materials used by artifact conservation and preservation. The collaboration between conservators and experts in other related fields, such as conservation science, computer science, radiography, digital imaging, and rapid-prototyping technology is critical to the successful practice of artifact conservation and interpretation.

DEDICATION

For my loving wife, Marsha, and my two wonderful children Monica and Chad.

Thank you all for your unfailing love and support over the years.

"I have taught you in the way of wisdom;

I have led you in right paths."

"When you walk your steps will not be hindered'

And when you run,

You will not stumble."

- Proverbs 4: 11-12

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TABLE OF CONTENTS

LIST OF FIGURES

Page

LIST OF TABLES

CHAPTER I

INTRODUCTION

Historical archaeologists depend upon artifacts as a prime source of knowledge about the near and distant past. These artifacts are analytically useful only to the degree that their meanings and uses in a historical context are understood (Schlereth 1985; Miller et al. 1991; Lubar and Kingery 1993). Past and current trends in material culture studies remind us "artifacts are a means to an end, that of teaching us something new of the past; they are three-dimensional additions to the pages of history" (Hume 1991:10-15).

The history and archaeology of edged weapons are the focus of an ever-growing academic community. The study of arms and armor is a multi-disciplined scholarly pursuit, as it appeals in a marked degree to the student of archaeology, historian, and to professionals working in the realms of art and material culture studies (Blair 1962; Wilkinson 1978; Ashdown 1995; Reid 1997).

Swords have been utilized as weapons and have appeared in multifarious varieties from pre-historic to present times (Thomas 1964; Wise 1974; Coe 1993; Harding 1993; Oakeshott 1996; Blackmore 2000). Their shape, design, and decoration were determined by their intended purpose, tactics of war, and technical requirements. Also, a sword's design and form may have been influenced by the dictates of fashion as is evidenced by the fact that hilt decoration became more and more elaborate over the centuries (Wilkinson-Latham 1977; Hoffmeyer 1979:52-79; Grancsay 1986; Byam 2003).

Apart from its function as a fashion statement, the sword is primarily a weapon; however, the physical forms of these objects resonate with the cultural meanings and symbolic themes associated with them. The construction techniques, material content, decoration, and inscriptions on the blades and hilts reflect the technology of the period, the expertise of the artisans and craftsmen, the origins of manufacture, and in many cases, the social, political, or religious affiliations of the owners of the weapons (Reid 1984; Westphal 1991:229-240; Odegaard 1995:187-193; Larocca 1996).

Historically, swords were associated with wealth and privilege and served as indicators of social status as well as badges of military rank (Ffoulkes 1945; Alexander 1992; Schutz 2001). It is important to emphasize and explain that swords are unique artifacts because of their dual nature as weapons and symbols. Therefore, the study of swords and arms and armor in general, are potentially important resources in terms of their material culture messages.

Despite the growing use and capabilities of gunpowder weapons in the late-18th century, the sword remained a functional and dependable sidearm for soldier, sailor, and civilian alike. Though the sword would remain a serviceable weapon for military establishments around the world well into the 19th century, its prominence on the battlefield waned by the mid-18th century.

The assortment of ordnance, small arms, and edged weapons recovered from the 17th century French shipwreck *La Belle*, are excellent representations of the conventional weapons utilized by the French military during the late 17th-century. The discovery and subsequent excavation of *La Belle*, uncovered a wealth of material culture (Bruseth et al. 2017). Among the ship's stores and equipment were a large number of swords and sword related artifacts (Arnold 1996:75-81). Of the "three hundred swords and sabers" requested by La Salle for his expedition to the New

World to establish a fort at the mouth of the Mississippi River, only a small fraction have been recovered (Cox 1905:187; Weddle 2001:98). Based on the number of recovered grips with intact hilt assemblies, an estimated eighteen complete swords have been recovered from the wreckage of *La Belle*. A total of seventy sword-related artifacts were eventually recovered and conserved from the shipwreck site (Kampfl 2017:480-498).

The historiography of edged weaponry has by and large focused on the description of armory collections, recent museum acquisitions, antiquarian catalogs, and collector's guides (Schöbel 1975; Held 1979; Norman and Wilson 1982; Weland 1991; Krenn and Karcheski 1992; Fliegel 1998). For this reason, current arms and armor scholarship seldom include a balanced evaluation of all types of evidence, focusing instead on broad discussions on developmental or artistic trends (Tarrassuk 1979; Earle 1980; Schwarzer 1986:2-50; Arnold and Godwin 1990:221-224; Redknap 1997; Pulak 1998:188-224).

One of the primary objectives of this dissertation is to explore and present an innovative, multi-disciplinary approach to the study of the swords and sword related artifacts recovered from the shipwreck of *La Belle*; a major goal being the development of a widening dialogue about swords and other edged weapons among historians, archaeologists, conservationists, and materials scientists. In order to accomplish this task, it is necessary to discuss the historical and archaeological context of the sword finds, and to accumulate data from numerous sources into this single volume. This analysis of *La Belle's* swords demonstrates that a strategy integrating different research methods is far more likely to produce significant results in terms of newly acquired material culture data.

Equally important, my research demonstrates that the use of innovative analytical techniques and the integration of new and existing technologies, which include new applications for radiographic techniques, rapid prototyping, digital and software applications, must become an integral part of the conservation process. Computer modeling technology coupled with active data acquisition techniques, such as computer tomography allows the conservator to document and interactively reconstruct artifacts, benefiting the future conservation efforts of various types of material culture by minimizing the risk to the actual artifacts. Newly acquired documentary, archaeological, and technical data derived through the conservation process, and application of new and innovative technology will provide invaluable data on the swords of *La Belle*.

Historic Context: La Salle and the New World

In the 16th century, the powerful Spanish Empire established lucrative colonies in the Caribbean, Mexico, and parts of South America. French interest in exploring the North Atlantic was in part, encouraged by a rapidly growing Spanish presence in the northwest in the 16th century her grasp on resources encompassed not only the Americas, but much of Europe as well. Initially, the French monarchy funded expeditions to the New World in hopes of finding a passage to eastern Asia, the original motivation of the Spanish explorations of the Americas (Farnie 1962:205-218; Morgan 1993; Hoffman 2002:24-37). By the first half of the 16th century, French exploration of the New World began in earnest.

In 1534, Jacques Cartier led a French expedition, sailing down the St. Lawrence River into a vast wilderness. These early explorations failed to locate a passage to Asia, prompting a change in strategy that eventually emphasized colonization to exploit the region’s vast natural resources. The French also realized that to contain the imperial ambitions of the other European states in

North America, namely Great Britain and the Netherlands, needed to establish a foothold in the New World (Conrad 1982; Miquelon 1988:432-443).

The French, as well as the Dutch and the English, sought new settlements in North America as a counterbalance to Spanish power in the Atlantic. The earliest French colonies in Florida were easily destroyed by the Spanish, who were more than determined to maintain complete control of the entire region. For this reason, the French decided to establish colonies farther north, in regions in which the Spanish had no interest, including the Atlantic coast of present-day Canada and the mouth of the Saint Lawrence River (Jaenen 2001:155-164). Initial attempts of the French at colonization in 1541 failed miserably due to extreme conditions and poor relations with the Native American population (Cook 1982; Trudel 1997).

In 1608, the French explorer Samuel de Champlain established a French settlement on the St. Lawrence River in Canada, near the site of present-day Québec City. Initially, Champlain's objectives were to locate a route through the North American continent to Asia, encourage a lucrative trade in furs and other commodities, and establish new French colonies throughout the region (Champlain 1878). Québec City, and eventually Montreal, would flourish as trading posts where Native Americans, including Algonquin and Iroquois peoples, came to trade beaver pelts and other commodities in exchange for European manufactured goods. Champlain, who had already spent several years exploring the Canadian frontier and meeting with indigenous peoples, had learned the techniques needed to successfully negotiate and trade with the Native American populations.

Champlain's success led to interdependency between the French and Native Americans in the fur trade. The French understood that they needed the skills of the native populations to obtain beaver pelts and were therefore willing to join in military alliances with them. French and

Native American trading partners confronted vast cultural differences in their approach to trade and diplomacy. Among Native Americans, trade was far more than a simple exchange of goods. Trade was closely connected with political alliances (Calloway 1997). Trading pelts for European goods became a highly ritualized affair that cemented trust between allies. By contrast, the French, like most Europeans, saw trade purely in commercial and economical terms, rejecting the notion that the Native Americans were equal partners in military or diplomatic alliances.

French and Native American cultures valued trade items according to different values (Trelease 1962). While the French recognized the European market value of beaver and other animal pelts, the Native Americans highly valued European manufactured items. Native Americans were especially interested in beads, kettles, knives, and other metal goods. It would not be long before simple manufactured goods would be replaced by guns, ammunition, and alcohol. This complex trading system made it difficult to negotiate equitable exchanges. Both sides learned to adapt to the other's trading systems (Ray 1978; Turgeon 1998:585-610).

Champlain was among the first Europeans to realize that the Native Americans looked upon trade not simply as an economic exchange, but as a part of a larger diplomatic, political, and even military alliance. Champlain did not let the cultural biases of his European upbringing impede his understanding that successful trade with the Native American tribes meant adapting to a unique situation in the new French colony. The French, to maintain good relations with indigenous trading partners, learned to speak Native American languages and accommodate native rituals. As a result, the Native Americans learned to treat their furs as a commodity with a negotiable price (Ray 1974: 26-34).

The mutual dependency between the French and the Native American population, sustained by the fur trade, ultimately had a destabilizing effect on Native American society on many levels, including an increase in hostilities towards Europeans and other natives. Consequently, the fur trade led to a growing demand among the Native Americans for European goods, which were increasingly valued for utilitarian purposes (Quimby 1966). Metal arrowheads, axes, knives, and hatchets proved more efficient than their stone equivalents. As a result, Native Americans gradually abandoned stone tools and weapons, losing those manufacturing skills and becoming more dependent on the European trade.

Tribes involved in the fur trade needed to expand. Continuous trapping lead to the steady depletion of beaver and other animals valued for their pelts. Entire regions could be trapped out in a matter of months (Carlos 1993:465-494). In order to obtain more beaver and animals, different tribes encroached on one another's territory, which caused increasing opportunities for conflict and violence. Access to new weapons, especially firearms, also made Native American warfare far more deadly than it was prior to contact with Europeans. The economics of the fur trade and the introduction of new weapons greatly expanded the scale and ferocity of the wars among Native American tribes and confederations (Adelman 1999:814-841).

The alliance the Huron and other tribes made with the French to maintain control of the fur trade alienated the Iroquois of the Five Nations, who were excluded from the exchange network. In 1610, the Iroquois began to obtain firearms, other metal weapons, and various manufactured goods from the Dutch, who were rivals of the French and had established settlements in the Hudson Valley. The Iroquois began to raid the territory controlled by the Huron, Montagnais, and Algonquin in the northern and western parts of New France, taking captives and causing destruction on a massive scale. The Native American allies of the French began to demand guns to defend against further Iroquois encroachment (Worcester 1984:103-115).

The changes wrought by Europeans in the Native American economy, the spreading of disease, and the introduction of firearms and alcohol among an already vulnerable population set in motion the Iroquois destruction of other Native American peoples. Warfare between the Huron and Iroquois reached large-scale proportions when, in the 1630s, European diseases, including smallpox and influenza, decimated Native American populations throughout the northeast (Naroll 1969:51-81). The Five Nations sought to repopulate their tribes by taking captives in war. From 1648 to 1650, they launched another series of decisive military actions against the Huron, and by the late 1650s, war captives may have constituted the majority of the Five Nations population (Garbarino 1994).

The opportunity for missionary work and the conversion of countless lost souls was not lost on the religious orders of France (Trigger 1965:30-53). The continued interaction between the French and Native Americans prompted some French officials and leaders of the Catholic Church to launch an effort to convert the Native Americans. In 1615, the French sent a limited number of Roman Catholic missionaries to live among the neighboring tribes. The missionaries were largely unsuccessful as conditions in the Canadian wilderness proved too harsh, and the Native Americans were at best indifferent to their message. It was only when representatives of the more determined Jesuit Order arrived in 1625 that the missionary movement gained a lasting foothold in Canada (Moore 1982; Richter 1985:1-16).

Concurrent French efforts to colonize its North American colony with immigrant families proceeded slowly but steadily into the 18th century, largely under the control of the monarchy (Moogk 1989:463-505). Although self-sufficiency in food and other necessities were the goals of the colony, the fur trade continued to dominate all other economic activities (Thomas 1935:41-60; Eccles 1983a:341-362; Eccles 1983b:341-362). After the destruction of the Huron by the Iroquois in the 1640s and 1650s, another tribe, the Ottawa, replaced the Huron as intermediaries between the French and the Native American tribes who did the trapping. During this period, hundreds of Frenchmen, known as *coureurs de bois*, traveled the western frontier to trade manufactured goods for high quality pelts, diverting the most necessary and active part of the labor force from agricultural production. These "runners of the woods" in fact, operated in the wilderness without securing a license from French colonial authorities.

French colonization in the 17th century was less spontaneous, more planned and regimented, than English or even Spanish expansion. French fur trading companies such as the *Compagnie des Marchands* (1613-1620), the *Compagnie de Montmorency* (1621-1627), and the *Compagnies des Cent-Associés* (1627-1663) were organized and subsidized by the crown, and granted lucrative fur trading monopolies. In 1663, Jean Baptiste Colbert, the Minister of Finance under Louis XIV, extended his mercantilist policies into New France, relieving the *Compagnies des Cent-Associés* of their administrative powers, conveying to the French Crown all their interests in Canada, making New France a royal colony (Dechêne 1992; Balesi 1992). To compete more effectively with England and the Dutch Republic, Colbert also subsidized an extensive shipbuilding program. His mercantilist measures aimed to ensure France's prominence in the New World and to provide the resources needed by the French government to finance Louis's wars of expansion (Bosher 1993:50-81).

Colbert's mercantilist policies enabled the Crown to assume direct responsibility of colonial government by 1678. Each colony in New France would now be presided over by a governor-general appointed by the Crown. The position of governor-general was usually held by someone with extensive military experience. By 1669, the governor-general was issued orders by the King to organize all male colonists between the ages of sixteen and sixty into military companies (Eccles 1972). Conflict between the French colonists and Iroquois had been escalating steadily since the early 1650s. An insufficient number of regular troops made the formation of colonial militia units necessary to hold off Native American threats and English incursions from the south (Aquila 1978:211-221).

Colonial governor-generals were assisted by an *intendant* who oversaw all the judicial, financial, and economic matters of the colony or territory. Governor-generals and *intendants* together were advised by nominated councils (*Conseil Souverain*), which also served as courts of appeal and performed other administrative duties. Jean Baptiste Talon served as the first Crown appointed *intendant* in New France (1665-68, 1670-72), reporting on colonial affairs directly to the King (Chapais 1914). An extremely able administrator, Talon promoted agricultural and commercial development on a broad scale, hoping to make the colony far less reliant on supplies and other materials from France. He was committed to maintaining the fur trade, but not at the expense of the colony as a whole. To this end, Talon greatly encouraged western expansion and the exploration of the North American interior. Several exploration parties were commissioned to increase French territorial possessions in the region and if possible, establish an overland or water passage to Asia. These explorers were also charged with locating new fur trapping territory and documenting the existence of any other exploitable natural resources discovered along the way.

Like Talon, Louis de Buade, the Comte de Frontenac, was of a mind to expand both French territory and the fur trade in North America (Eccles 2003). Although their intentions were the same, their motives and methods varied considerably. Prior to his service in New France, Frontenac spent more than thirty years as an active soldier in Europe and as an extravagant, irascible, and pretentious courtier. His appointment as governor-general in 1672 enabled him to defer payment on enormous debts he had accrued over time in France and to profit greatly from the fur trade during his tenure as governor-general of the French colony in Canada.

Frontenac's first term in office (1672-82) was marked by incessant quarrels both with subordinate officials over jurisdiction and precedence and with the Jesuits over-certain moral issues, usually involving the sale or trade of liquor and guns with the local Native Americans (Delanglez 1939). Frontenac did manage to promote the western fur trade by sponsoring the endeavors of explorers and soldiers such as Daniel Greysolon de Du Luth, Nicolas Perrot, and Henri de Tonty, among others.

War with the Anglo-American colonies and their Iroquois allies dominated Frontenac's second term (1689-98). Frontenac successfully defended New France from English and Native American attacks by means of a guerrilla war of attrition (Eccles 1998). By building several new forts in the west and southwest regions of territory claimed by the French, he not only expanded the French fur trade, but also laid the groundwork for strategic control of the lands west of the Appalachian Mountain ranges in North America.

Eventually, the paths of Talon, Frontenac, and Robert Cavelier de La Salle crossed. La Salle was personally associated with Talon and Frontenac and became a fervent supporter of their expansionist ideas (McInnis 1959). The influence of these two men, along with La Salle's own quixotic character and incorrigibly fractious temperament, eventually led the impetuous and intractable explorer down a path from which he never returned.

René Robert Cavelier, Sieur de La Salle

The French fur trader and explorer René Robert Cavelier, Sieur de La Salle, was arguably the first European to explore the lower Mississippi River. Born at Rouen, France on November 21, 1643, he spent nine years as a Jesuit novice, studying logic, physics, and mathematics. In 1667, however, he left the order and sailed for New France. La Salle's brother, Abbé Jean Cavelier, served as a priest of St. Sulpice and had already gone to New France where the Sulpicians held the seigniory of Montréal. Possibly the association of an uncle, Henry Cavelier with the fur trading *Compagnies des Cent-Associés* , and a distant cousin, Jacque Le Ber, an established merchant in Montréal, also peaked La Salle's curiosity in the developing French colony (Terrell 1968; Osler 1967).

La Salle received a land grant from the Sulpicians, and by 1669, he had established himself as a successful seigneur near Montréal. To facilitate agricultural development and encourage settlement, French Finance Minister Colbert retained the system of feudal *seigneuries* in New France, but made them conditional upon effective occupation. The Crown granted a section of land to a *seigneur* (landlord), who in turn leased concessions to settlers (Diamond 1961:3-34). La Salle was far from content with farming the land and began to dabble in the fur trade.

La Salle's schemes did not fully develop until about 1673 when he became an avid supporter of the Frontenac's policy of western commercial and military expansion of New France (Terrell 1968). He eventually received a commission and was appointed commandant of Fort Frontenac on Lake Ontario and charged with the development of the fur trade in that area. Under Frontenac's sponsorship, La Salle traveled in 1679 to Lake Michigan, in 1680 to the Illinois country, and in 1682 from the Illinois River down the Mississippi to where it emptied into the

Gulf of Mexico, thus discovering the mouth of the Mississippi River in 1682. La Salle claimed all the land drained by the Mississippi River in the name of King Louis XIV of France. This claim would prove critical for the future United States by becoming part of the Louisiana Purchase in 1803. Four new forts, Niagara (1679), Saint Joseph and Crèvecouer (1680), and Saint Louis (1682), were established in the northwest (Johnson 2002). The first sailing ship, the *Griffon*, was built by La Salle and his lieutenant Henri de Tonty (1679), and was launched on the Great Lakes above Niagara (Talman 1959; Quimby 1966).

Profits from the fur trade were intended to finance these and further explorations, but political setbacks, bad organization, and bad luck turned such high expectations into deepening debt. After Frontenac's recall to France in 1682, La Salle lost a valuable source of patronage and had to spend nearly a year lobbying at the French court to regain official support and funding. When it finally came in 1684, it was generous (Weddle 2001).

Supported by the French king Louis XIV, La Salle laid claim to the territory that he had named Louisiana, stretching from the Illinois country to the Gulf of Mexico, and beyond into the interior of New Spain (Muhlstein 1994). To secure this claim, he was supplied with four ships to establish a fort at the mouth of the Mississippi River, by Louis XIV: *Le Joly*, *Le Saint-François*, *l'Aimable*, and *La Belle*. La Salle's mission was essentially two-fold. He was to sail to the mouth of the Mississippi River delta and establish a fort. From the fort he would penetrate Spanish territory, and exploit the silver mines he was expected to locate (Wood 1984:294-323). The materials and supplies carried by the four ships would be used to construct a new French colony on the mouth of the Mississippi river (Chesnel 1932; Weddle 1991).

The expedition set sail from France on August 1, 1684 with nearly three hundred sailors, soldiers, and settlers bound for the New World. *Le Saint-François* was taken by Spanish pirates as La Salle's small fleet approached Saint-Domingue. *L'Aimable* ran aground trying to enter the safety of Matagorda Bay, which he erroneously thought was the mouth of the Mississippi, not realizing he had missed it by some three hundred miles to the east. The loss of *Le Saint-François* and *l'Aimable* seriously hampered La Salle's effort to locate the true Mississippi River delta, let alone establish a permanent French colony and harass the Spanish.

The incessant arguing between La Salle and Taneguy Le Gallois de Beaujeu, the captain of *Le Joly*, ended with Beaujeu sailing *Le Joly* back to France, talking with him half of the intended colonists, his mission completed (Muhlstein 1994; Weddle 2001; Bruseth 2005). Now only the *Belle* remained; a solitary lifeline between the dwindling number of would-be colonists and civilization. Ten months later, in January 1684, *La Belle* would strike a hidden sand bar and join *l'Aimable* at the bottom alongside a hidden sand barrier island near the entry into the Matagorda Bay, leaving the colonists to their fate.

La Salle failed to rediscover the Mississippi delta from the Gulf side and two of his own men finally assassinated him in Texas in 1687. Nearly all of the soldiers and settlers left behind died from starvation or disease; many others met their end at the hands of hostile Karankawa Indians. By January 1688, Fort Saint Louis lay in ruins. Three months later, a Spanish scouting party led by General Alonso de León, found the ruined fort and the few remaining French colonists (Bolton 1915:165-182; Gilmore 1975; Tunnel 1998:19-44).

Exploration is a quest for the unknown. Explorers have been motivated by curiosity, by a desire to find fame and fortune, and by the need to find a location for surplus populations. Some have explored by accident, others because of military campaigns, but most have explored by design. La Salle's great projects and plans, his ambitious ideas and hopes, have blinded his biographers to the fact that most of his failures were due to his own shortcomings. Both condemned and admired by his contemporaries, he was a visionary without adequate executive power to carry out his schemes.

In the end, La Salle's lack of success should not obscure his accomplishments, both as an explorer and as one of the architects of French expansion into the North American interior. He understood the significance of controlling the Mississippi Valley in terms of both economic development and military strategy. He was undoubtedly the first of the French explorers to follow the Mississippi River to its delta. Any judgment of La Salle must be tempered with careful deliberation because his oversights and failures were committed in the name of his undeniable quest, the discovery of an empire for France in the heart of North America. In 1995, the last of La Salle's four ships, *La Belle* was discovered and eventually excavated in 1997; yielding a wealth of material culture, adding yet another chapter to the La Salle saga.

Archaeological Context: *La Belle* Discovery and Excavation

Throughout the 1970s, the Texas Historical Commission conducted extensive archival research in hopes of discovering the approximate location of *La Belle*. In 1995, while conducting a series of underwater magnetometer surveys in Matagorda Bay, Texas, the Texas Historical Commission located the wreck of *La Belle*. *La Belle* was one of four ships belonging to French explorer René Robert Cavelier Sieur de La Salle (Arnold 1996:66-87).

The excavation of the *La Belle* shipwreck (Site 41MG86) was directed by Dr. James E. Bruseth, the Director of the Archaeology Division at the Texas Historical Commission (Bruseth 2005). The ship sank slowly settling on the bottom of the bay approximately 3.6 meters from the surface. Poor visibility and rough seas made an underwater excavation extremely difficult. The best way to avoid the hazards of an underwater excavation was to turn the *Belle* shipwreck site into a terrestrial excavation (Roberts and Chernush 1997:40-55; Bruseth 2005). The underwater excavation took place over a continuous period, between July 1996 and May 1997. Nearly one million artifacts were recovered from the site. The artifacts and deep layers of ocean sediment covered the remains of *La Belle*, protecting and preserving 20%-30% of her wooden hull. The hull was disassembled in situ. All of the artifacts along with the hull timbers were sent to the Texas A&M University Conservation Research Laboratory, under the direction of Dr. Donny Hamilton (Hamilton et al. 2017:60-80).

Chapter two discusses the history of Robert La Salle; from his days as a fur trader and explorer in New France, to his failed attempt to establish a French colony on the mouth of the Mississippi River. This chapter also examines La Salle's expedition from a military perspective, arguing that La Salle's lack of experience and ability as a military commander, coupled with inadequately trained troops doomed the expedition to failure. Attempting to establish a colony in a region which had not been fully explored or secured against potential enemies was foolhardy at best.

Chapter three examines the history and archaeology of the sword. Advancing the need to develop and utilize a concise and accurate sword nomenclature, lends itself to a better understanding of the development, anatomy, and use of this type of weapon. Chapter four provides a descriptive analysis of the swords discovered on site, an in-depth interpretation of the relationship between the swords and other weapon types excavated from the *La Belle* shipwreck site, and considers the relevance of these swords to the field of arms and armor study. This research combines data obtained during the conservation process, comparative artifact analysis, and existing documentary evidence to present an in-depth study of the *La Belle* sword assemblage.

A sword hilt is a composite artifact; constructed of wood, leather, metal, and various metal alloys. Composite objects, specifically those constructed of organic materials and metals are often difficult to stabilize. If possible, the artifact must be broken down and treated as individual organic and metallic components. The conservator must first stabilize an artifact before the conservation process can begin. Chapter five details the documentation and conservation processes used to stabilize and treat the sword related artifacts recovered from *La Belle*.

Chapter six elucidates the application of a broad spectrum of analytical methods and technology to the conservation process, which is crucial to the understanding of the material makeup and technical aspects of the swords (Lang 1988:199-216; 1989:85-122; Henderson 1989; Jolly and White 1995; Cilibert and Spoto 2000). The use of radiographic techniques, 3-D printing technology and 3-D modeling software continues to play a vital role in conservation, and its advantages are discussed in this study. More recently, computer tomography is being used to produce data that is used to create three-dimensional models of artifacts in a variety of synthetic materials, such as wax, resin powder, and various plastic compounds, which will aid in the retention of the diagnostic features of the original artifact.

CHAPTER II

LA SALLE'S ARMY

Establishing a permanent presence in the Gulf region was, from a strategic standpoint crucial for the French. The threat from international rivals, the constant danger of pirate attacks, not to mention the likelihood of encountering hostile natives once ashore was ever-present. Though a tenuous peace was in effect between France and its erstwhile enemy Spain at the time, the large store of weapons discovered onboard *La Belle*, and the presence of the warship *Joly* serving as escort, indicates that sailing to the distant reaches of the New World would be a hazardous undertaking. Into this hostile world La Salle brought three hundred would-be colonists, nine of them women and children.

Though La Salle discovered the mouth of the Mississippi two years earlier some three hundred plus miles to the east, he knew relatively little about the surrounding geography and native peoples. La Salle's first mission, once the mouth was located, should have been a strictly military undertaking; securing the territory around the Mississippi Basin, and assessing other potential risks to any future colony. The journey from France to the Gulf of Mexico was beset by one disastrous mishap after another. Instead of locating the mouth of the Mississippi, La Salle's fleet landed farther down the Gulf of Mexico coast, near of present-day Texas, missing their intended destination by nearly four hundred miles.

This dissertation focuses on the edged weapons of *La Belle*, yet in order to understand the weapons, it is necessary to understand the men who wield them. The Royal French Army was, by the late 17th century, becoming a well trained professional fighting force. Well-armed and equipped, regular troops were sent throughout the empire to maintain security and defend it against the enemies of France. In direct contrast to this, the workmen and soldiers hired by La Salle and his agents were utterly incompetent and anything but professional.

The historical record is scant and reveals very little about the men employed as soldiers by La Salle (Appendix A). Were any of them professional soldiers or veterans of past campaigns? What type of weapons training did any of them have using firearms or bladed weapons? Did any among them have any experience in the wilds of North America? The weapons discovered on *La Belle* were state of the art; deadly in the hands of well-trained disciplined soldiers. As La Salle's plans to establish a French colony in the New World began to unravel, it would become painfully clear that his men lacked the necessary training and discipline required establish a foothold on the Texas coast.

The French Army

In the 17th century, standing armies were created to serve the states and monarchs of Europe. European rulers and diplomats have always sought to defend and expand the power of their states. By the mid-17th century, concern for the security and aggrandizement of the sovereign state took precedent over all other considerations (Bean 1973:203-221; Clark 1985; Lachmann 1989:141-162; Morillo 2004). The state embodied its own ends and recognized no higher authority than its own highly centralized-government. States employed all necessary means, including war, to achieve their political objectives. In an international system where armed conflict or all-out war was an ever-present prospect, a strong military was an essential component of national power (Barker 1982; Duffy 1988; Lynn 1994:178-204; Lynn 2005:167-188). As a result, the ability of a state to protect its interests and to wrest what it wanted from others was, in large part, a function of the effectiveness of its military might. The French military would become the most vital instrument of national policy, and the success or failure of the military played a significant role in determining the future of French foreign policy (La Gorce 1963; Symcox 1991; Lynn 1997:3-30; Parrott 2001:84-110).

Given France's geographical position, both Royal and later Republican governments devoted most of their fiscal resources to the army. There were French imperial ambitions and the need to protect her overseas possessions, therefore the navy was also a primary concern, at least under the French minister Jean-Baptiste Colbert (1669-1683) and his son who would succeed him as Minister of the Navy, the Marquis de Seignelay (1683-1690) (Corvisier 1964; Pilgrim 1975:235-262; Trout 1978; Murat 1984; Pritchard 2004:234-240). Still, Louis believed that diplomatic and military events on the European continent contained the most serious threats to French security and provided the best opportunities for the expansion of the state's power and influence (Lynn 1994: 178-204; Rowlands 2002).

The French military reflected in its structure and organization many of the social and class tensions that existed in the civil world, the army resembling in broad outline the society that created it (Weygand 1938; Barker 1982; Martin 1991:111-126; Tucker 2001: 1057-1095). During the period of the *Ancien Régime*, the army was steeped in an aristocratic tradition. Though lacking any real training in the use of military strategy and tactics, the nobility provided most of the officers, while the service ranks came from the lower social orders. The French army developed its own tactical doctrine which, in turn, dictated the nature of war and the effectiveness of both strategy and military aims. The tactical system was in large measure a function of the army's social composition and the state of the art of weapons technology (Lynn 1985:176-191). Because of this, military commanders had to operate within the constraints imposed by tactical doctrine while seeking to make the most effective use of the capabilities inherent within the system.

The French army was a major consumer of money and technology. The throne had to equip, pay, and supply the armed forces, which proved to be both a financial and organizational burden. The French army's history is without a doubt linked to the destiny of the nation, in both the domestic and foreign arena (Lynn 1999:47-104).

Weaponry

When Louis XIV ascended the French throne, infantry had nearly supplanted cavalry as the main military force in battle. Battles on the Continent were generally decided by foot soldiers deployed in linear formations, trading volleys with the enemy. Cavalry was used primarily for scouting and pursuit and only rarely for the massed charge (Palmer 1972; Childs 1982; Lund 1999:65-77; Black 2006:87-118). Between the 15th and 17th centuries, gunpowder weapons were changing strategies employed on the battlefield. The appearance of the matchlock or firelock musket made it possible for tightly packed infantry formations to engage cavalry without having to engage directly in close combat. Originally the word musket (*mousquet*) referred to a matchlock arm, and in France at the end of the 17th century was used in contradistinction to the flintlock (*fusil*) (Lenk 2007:26-40).

The musket was equipped with a succession of firing mechanisms during its three hundred year history. In the matchlock, a spring device dropped a lighted match or wick directly into the gunpowder charge. A slight improvement over the matchlock, the wheel lock utilized a trigger mechanism which brought a small piece of iron pyrite into contact with a rotating wheel; the resulting spark ignited the powder. The flintlock used a similar flint-on-steel mechanism, but was infinitely easier to load and cheaper to manufacture (Petersen 1947:197-208; Brown 1981; Hughes 1997:26-29).

Muskets with rifled barrels were experimented with during the 17th century, but not on any large scale. Special regiments or infantry units partially armed with rifles and carbines appeared in France under both Louis XIII and Louis XIV. Despite the added accuracy and increase in range, rifled weapons had several drawbacks. Soldiers using rifled muskets or carbines required more training than those using smoothbore weapons. Rifled barrels were more difficult to load, and tended to foul quickly resulting in the need to clean the weapon more frequently. The inability of 17th-century European nations to manufacture rifled barrels on a large scale meant that the cost of these weapons would remain excessively high. For these reasons, the flintlock did not become the standard issue firearm in the French army until the beginning of the 18th century (Lenk 2007:93-108).

The slow rate of fire of these early short-range weapons also required that musket wielding infantry be protected from the hostile advance; a problem solved by interspersing soldiers armed with a pike throughout infantry formations. A pike is a type of pole-arm weapon, which consists of a steel blade or spearhead fixed to a long wooden shaft. Approximately 3 to 7.5 meters in length and weighing between 8 to 10 kilograms, pikes were the largest of the pole arm weapons. Because of their great size the weapons required two hands to wield effectively.

In the early 17th century, the Spanish developed a new battlefield formation known as the Tercio. The Tercio combined the defensive power of the pike with the offensive power of the firearm. The immense length of the pikes allowed a significant concentration of spearheads to be pointed at the enemy, keeping advancing infantry and charging cavalry at bay, but also made pikes unwieldy if the pike square or line was breeched by the enemy. This meant that pikemen had to be armed with close combat weapons such as a sword or dagger and possibly a small shield should the fighting evolve into a melee (Featherstone 1998; Jörgensen et al. 2006:8, 15-24, 40-56).

The Tercio or “pike and shot formation” as it came to be called, was soon adopted by the other military establishments of Europe. The size and composition of the enemy forces, along with other tactical considerations such as the topography and condition of the battlefield, would determine the size of the formation, pike to shot ratio, and the deployment of these units on the battlefield (Roberts 1995:13-35; Steele and Dorland 2005:77-85). Technical improvements and the ability to produce firearms in greater quantities led to an increase in the number of men armed with muskets in the pike and shot formation. The development and widespread use of the detachable bayonet would eliminated the need for a separate corps of pikemen altogether.

First used in the mid-17th century, the bayonet proved beneficial as an additional infantry weapon for close combat. Early bayonets consisted of a blade and handle, also referred to as a plug. The plug bayonet would effectively turn the musket or flintlock into a pole weapon; the obvious drawback being the musket or flintlock could not be fired or reloaded quickly while the bayonet was still lodged in the barrel. By the last quarter of the 17th century, the armies of Europe were slowly being outfitted with socket bayonets, but they were not fully adopted by the French until 1703 (Evans 1985; Thompson 1999:59-77). The combination of the smoothbore flintlock musket and socket bayonet enabled the infantry soldiers to withstand the shock attack of mounted troops.

During the 15th century the French and Italians attempted to make artillery more mobile by mounting some of the lighter pieces on carriages. A key technical development was the trunnion: two posts, one on either side of the cannon barrel near the balance point, fixed the tube to the mount, permitting it to be raised or lowered by pivoting on the trunnion. By the 17th century, the range and effectiveness of artillery had significantly improved. The Swedish King Gustavus II (r. 1611 to 1632), developed effective tactical methods for using artillery on the battlefield (Brzezinski 1993:3-10; Doughty 1996:3-28; Norris 2000:74-78, 86, 104). Gustavus limited his field artillery to nothing heavier than the 12-pounder, and he increased the ratio of cannon from one gun to six for every one thousand infantry. He concentrated his firepower, frequently massing guns in strong batteries, and utilized the distinctions among siege, field, and regimental artillery.

By the middle of the 17th century, European nations would begin to maintain standing armies, with artillery became an organized arm of the military. Louis XIV of France raised a regiment of artillerymen in 1671 and established schools of artillery instruction. Large sea-going vessels proved to be excellent artillery platforms, and it was onboard ships that the application and development of artillery would improve dramatically (Lambert 2000:23-50; Woodman 2002:21-23, 53-55).

Recruitment and Training

Louis required more and more men to fill the ranks of his swelling army. Recruiting the necessary quota of men became increasingly difficult; and as René Chartrand (2005a:11) observed, "…the quality of the men declined as the numbers increased." Considering the ever-increasing size of the regular army and provincial militias during the late 16th century, and the escalating number of military actions being taken by Louis, any inquiries into the methods, successes and failures of Louis's recruiting policies, must beg the simple question:

> How was it that so large a proportion of inexperienced, often unwilling men, scantily, if at all committed to a cause and given little or no preliminary training, could be turned into adequate, on occasion conspicuously brave combat soldiers (Hale 1998:153)?

Louis XIV inherited an army that was still semi-feudal. Nobles dominated the Officer Corps. Individual regiments answered more to their colonel-proprietors or captains than they did the Crown. Generally, the captain of each company or one of the lieutenants was responsible for recruiting, outfitting, and arming new troops. Using government funds, officers raised, trained, and supplied their units. There were little if any standardized drill codes, or organizational procedures in place. In time, however, Louis and his ministers did manage to transform the army into an effective instrument of government policy (Lynn 2002:111-144).

Military regulations provide basic insights into the inner workings of the French army. They offer a detailed picture of the structure and function of combat units and of the logistic and administrative services. The evolution of the army's organization and the results of periodic reform efforts by the Crown and able, ministers with military experience are reflected in the constructive changes that appear in military regulations and drill manuals. These also reveal the outlook of the Old Régime military on a wide variety of issues, including discipline, justice, pay scales, promotion, education, medical care, dueling and military equipment. Results of reform efforts in these areas are also reflected in the regulations (Baxter 1976: Doughty 1996: 3-60; Black 1998:871-892; Lynn 2000:35-56).

Military strategy and tactics are essential to the conduct of warfare (Rothenberg 1986: 32-63; Clauswitz 2007). The increasing complexities of 17th-century warfare demanded a government capable of recruiting, administering, and supporting massive armies. As warfare evolved and firearms and artillery were introduced, the demands on military skills proliferated and led increasingly to the need of a progressive training system for field officers and troops (Hacker 1994:768-834; Howard 2001:54-74).

By the early 17th century, military drill manuals supply basic evidence concerning tactical doctrine and its development (Saint-Rémy 1939; Chandler 1976; Kleinschmidt 1999:601-629). Jacob de Gheyn's *Exercise in Armes*, first published in 1607 was used extensively to drill soldiers in the "correct and efficient way" of handling their weapons (Gheyn 1999). *Le mareschal de bataille* by Colbert de Lostelneau (1647) instructed officers in complex military tactics and strategies. Louis de Gaya's (1678) classic *Traité des armes* is a superb treatise dealing with 17th-century arms and armor. These military manuals offer a unique insight into the key developments in training, organization, tactics, and weapons proficiency during the period of the so-called military revolution (Parker 1988; Black 1991; Dorn 1991:656-658; Rogers 1995: 299-333; Hacker 1997:461-487; Black 2004:151-173).

From the beginning of Louis XIV's reign to the outbreak of the Revolution, France, like other European nations was engaged in a constant round of hostilities. Many of these encounters involved operations overseas and were in a sense wars of empire and expansion. The success or failure of French policy was in large measure determined by the results of French strategy and tactics. For this reason, having some knowledge of French military doctrine is crucial for the understanding of the European struggle for power as well as the quest for imperial dominance in the New World (Kennett 1967; Eccles 1987:156-159; Sahlins 1990:1423-1451; Pritchard 2004).

The colony of New France would develop slowly over the years, facing a hostile environment as well as the constant threat of attack from the warring Iroquois nations, allies of the English (Verney 1991:4; Dennis 1995). A renewed interest in the potential flow of wealth from the colony during the early 1660s, would compel Louis to place New France firmly under crown control by 1664 (Harris 1966:109, 171-172; Griffiths 1992; Greer 1997; Pagden 2001:90; Taylor 2001:363-395). The inhabitants of the beleaguered colony greeted this news with a great deal of optimism.

Under several capable administrators, the economy and population of New France would grow, however the problem of dealing with the Iroquois remained a critical issue requiring immediate attention (Costain 1954; Jennings 1990:172-185; Adelman 1999: 814-841). A sustained letter writing campaign by acting colonial administrators requesting aid against the Iroquois, and a promise kept by Colbert to send regular troops, resulted in the dispatch from France of the first royal troops to serve in Canada.

French Colonial Troops: Recruitment, Training, and Weapons

On 19 June 1665, the French ship *Joyeux Siméon* docked at Quebec to disembark the first four companies of the Carignan-Salières Regiment (Verney 1991:18). The regiment at full strength was comprised of twenty companies for a total of one thousand officers and men. The Carignan-Salières formed in 1658 as an infantry regiment serving in the Royal French Army, which by 1661, had grown significantly in size, and was beginning to resemble a fairly modern standing military force (Chartrand 1984). The men serving in the Carignan-Salières Regiment were recruited by regimental officers in France as the need for manpower arose.

Seventeenth-century European warfare consisted of large, somewhat maneuverable formations of infantry drawn up in ranks, releasing ordered volleys of musket fire into the enemy. The men of the Carignan-Salières Regiment were highly trained in this manner, and drilled to respond quickly to commands while maintaining a high level of proficiency with their weapons. Most of the troops were issued the standard matchlock musket; however the first companies to embark for New France were issued flintlock muskets with bayonets. A total of two hundred flintlocks were issued along with pistols and adequate supplies of powder and ball. The regiment did not bring pikes to the colony, but each soldier was armed with a sword. Of note is the fact that French troops, like the volunteers of the colonial militia soon learned to discard their swords when serving in the field for the less cumbersome hatchet.

The scale and type of warfare waged between Native Americans and early European colonists has been the subject of an ongoing debate between scholars of military history (Starkey 1998; Chet 2003; Shannon 2008:35-48). Once entrenched in the New World, the Europeans engaged in sporadic warfare with the local populations of Native Americans, establishing military and trade alliances (White 1991:94-190; Usner 1992: 26-31; Given 1994:49-56; Skinner 2008:10-25). The natives appropriated European weapons, effectively adapting them to their own tactical and strategic traditions. Native Americans rarely committed to an outright battle, preferring hit-and-run raiding, ambush, and attacks on isolated targets.

The soldiers of the Carignan-Salières Regiment arriving in New France would face a new enemy and a decidedly unorthodox type of warfare. "The troops did not even begin to learn the nature of Indian warfare until a number of them had been killed under such circumstances," Jack Verney (1991:55) writes, "it was a lesson difficult to learn for men trained to believe that war consisted of set-piece battles, fought on open ground with the enemy clearly in view."

Consequently, the militia men and regular troops were instructed by their Native American allies, in the use of canoes, snowshoes, moccasins, and leggings, and the hit-and-run tactics of "la petite guerre" (Malone 1991:67; Grenier 2005:13-52).

The experienced veterans of the Carignan-Salières Regiment were frequently employed to train the colonial militias in the use of military weapons and tactics, though the military efficiency of the colonists had, over the years become considerable. The settlers were well motivated and disciplined, and their military service was, in light of the Iroquois threat and the proximity of the English colonies, an inevitable consequence of their vulnerable state in the wilds of Canada (Munro 1918; Otterbein 1964:56-63). Most of the French colonists had long since acclimated to life in the harsh environs of New France. They were extremely adapted at surviving in the woodlands and navigating the many waterways that crisscrossed the north-east territories (Eccles 1983a). Campaigns against the Iroquois and English were always carried out with regular troops supported by a large number of volunteer militia forces, and smaller contingents of allied Native Americans (Eccles 1975:1-21; Gallup 1992; Johnson 2003:7-11).

The regiment was given leave to return to France in 1668. Most of the troops returned to France; however a large number of soldiers chose to remain in the colony as permanent settlers. In order to maintain a state of military readiness, Louis ordered the acting governor of New France, Daniel de Rémy de Courcelle to reinforce the remaining professional troops with colonial militia in 1669:

> You will learn from His Majesty's letters what he wants you to do in order to keep the habitants trained in the use of arms, and in military discipline, and you must consider this to be of the utmost importance

> and the one thing that will contribute most towards maintaining, augmenting, and fortifying the colony…(Verney 1991:116).

Throughout the first half of the 17th century, Louis launched many small-scale military operations to expand and secure France's trading empire and colonies around the world. In 1664, a small fleet of ships carrying six hundred and fifty settlers and four infantry companies sailed from La Rochelle. The commander, a high ranking officer and battle-tested veteran, Alexandre De Prouville, Marquis de Tracy was given the task of driving the Dutch out of the West Indies. The Marquis de Tracy continued on to Canada where he was given overall command of the Carignan-Salières Regiment, and charged with checking Iroquois aggression against the colonies of New France.

Louis XIV commissioned another Frenchman, La Salle, to extend his imperial reach, securing Frances' position as the predominate power in North America. A former Jesuit novice turned fur trader then explorer devised a fantastic plan, which if successful, would greatly increase France's territorial possessions in the New World, and put her in an ideal position to challenge Spain's dominance in the Gulf of Mexico (Villiers du Terrage 1934). Four ships would set sail from France in 1684, laden with supplies, equipment, weapons, and a hodge-podge of would-be colonists and hired hands. Within two years, most of the colonists were dead, and the leader of the expedition assassinated, his dreams of wealth and fame dying with him.

La Salle's Military Objectives

In 1682 René Robert Cavelier, Sieur de La Salle made his grand journey by water down the entire length of the Mississippi to the Gulf of Mexico and opened up a wide range of strategic and economic possibilities. The intrepid explorer claimed the entire drainage basin for France and her king in 1682. La Salle understood that establishing control of the Great Lakes region and the Mississippi River delta, as Iberville and Bienville proved in 1699; was the only way to maintain French domination of the territory west of the Mississippi River Valley (Gravier 1870; Margry 1886:292; Cox 1973:196; Brasseaux 2000:1-15; Garvey 2006:17-20, 30-35).

The entire distance could be covered by several alternative water routes, with comparatively short portages. Lines of communication could be safeguarded by forts covering the key portages and the narrowest stretches of water. The plan presented by La Salle to the French court in 1683 may not have been this far-reaching, though it seems he was well aware of the need to establish a French presence in the Gulf of Mexico if Spanish hegemony in the region was to be challenged (Holmes 1982:106-128; Bell 1987:225-258; Weddle 1991:15-19).

La Salle's mission was one of exploration and settlement. It was also a mission with a contrived military objective. The incorrigible Spaniard, Diego Dionisio de Peñalosa, a former colonial governor and Spanish turncoat, proposed a plan which involved establishing a colony at the mouth of the Rio Grande River as a base for conquering Nueva Vizcaya (New Biscay). His plan bore some resemblance to the proposal set forth by La Salle, who in 1683 returned to France from North America seeking support from the French king Louis XIV for his future endeavors. Peñalosa did not obtain the French aid he was seeking. Whether or not Peñalosa's scheme influenced La Salle has been the subject of endless historical debate (Shea 1852; Miller 1901; Delanglez 1938; Freytas 1964).

The dubious nature of the contemporary sources referencing the relationship between La Salle and Peñalosa and their far-reaching dreams of conquest, make any realistic interpretation of these developments problematic at best. An indecisive and slightly bewildered La Salle, the machinations of an ambitious Spanish renegade, and the incessant scheming of the unscrupulous

Abbés Bernou and Renaudot, make it extremely difficult to fully comprehend La Salle's initial motives and plans (Weddle 2001:87-95).

Despite the many intrigues and obstacles set in his path, La Salle was able to present a viable if not slightly fictionalized plan to the French court (Wood 1984:297 Weddle 2001:94). The exact nature of La Salle's mission is debatable. It was no secret that Colbert, and later his son Seignelay, advocated the establishment of a French port in the Gulf of Mexico as a deterrent against Spanish aggression in that region (Pilgrim 1975:235-262; Balesi 1992:3-7). That La Salle's original plans included an all-out attack against the Spanish silver mines of Nueva Vizcaya is still uncertain. Many La Salle historians and biographers questioned the feasibility of such a plan, believing it militarily and tactically unsound:

> Unless we assume that his (La Salle) scheme for invading Mexico was thrown out as bait to the King, it is hard to reconcile it with the supposition of mental soundness. To base so critical an attempt on a geographical conjecture, which rested on the slightest possible information, and was in fact a total error; to postpone the perfectly sound plan of securing the mouth of the Mississippi to a wild project of leading fifteen thousand savages for an unknown distance through and unknown country to attack an unknown enemy, was something more than quixotic daring (Parkman 1902:362-363).

Jean Delanglez (1938:94-95) is less forgiving as he states:

> An assault upon the Spaniards under the circumstances with a handful of soldiers may be readily admitted as preposterous, but was not the entire scheme upon which La Salle had embarked, absurd?

Whatever his long-term objectives were, ultimately the French explorer's mission meant that he had to establish firm control over the Mississippi River Valley. The success of any such mission would depend largely upon his ability to establish a secure base where the Mississippi River emptied into the gulf. A secure defensible stronghold in the delta range would put La Salle in an ideal position to challenge Spanish control of the gulf, as well as receive reinforcements and supplies from French forts in the Illinois territory via the Mississippi River (Jacks 1931:273-275; Weddle 2001:90, 93-94). Controlling the mouth of the river would also provide France with a badly needed warm water commercial port (Osler 1967:34; Bruseth 2005:18; Garvey 2006:30-37). It is not surprising that Louis would have been won over by such a plan.

La Salle as Military Commander

Whether the mines of Nueva Vizcaya were truly La Salle's intended target or not, those involved with the planning of this expedition to the Gulf of Mexico would have known that a confrontation with the Spanish was inevitable. Fortifications are constructions designed to increase the fighting power of troops occupying a strategic position (Wilson 1965:103-110; Vauban 1968:54-76; Duffy 1979:247-249; Mahan 2005: 1-6; Chartrand 2008). The tools, building equipment and construction materials discovered aboard *La Belle,* suggests that the La Salle expedition was fully capable of constructing a fort or block house to safeguard the mouth of the Mississippi River (Bruseth 2005:104-105; West 2005).

With or without the aid of the rancorous engineer Jean-Baptiste Minet, La Salle was confident he could manage the construction of any fortification quite easily. In 1675, La Salle was given command of Fort Frontenac in New France. The original fort had been a simple structure consisting of a number of crude wooden palisades. La Salle later rebuilt the entire fort, including several new support buildings, entirely in stone (Lockridge 1931:42-43; Weddle 2001:41-42; Bruseth 2005:18; Chartrand 2008).

In 1678, Louis XIV afforded La Salle the opportunity to construct a chain of forts across New France which would serve as bases for the fur trade, colonial defense, and further exploration. La Salle did possess the knowledge and practical experience of designing and constructing forts, however as Minet (1987:108) points out he cannot do it alone. Minet's journal also provides several very useful insights into the military preparedness and organization of the La Salle expedition prior to its departure from France.

> He [La Salle] was given 100 men-and would have to raise 100 at his own expense-powder, arms, some Pétard cannon, and the *Joly*, a third-class vessel, Monsieur [Tanguy Le Gallois] de Beaujeu, captain of the vessel, to take charge of it, and an engineer. The officers of this troop should be people who knew the savages. Nevertheless, he sold a portion of the commissions that Monsieur Morel had given him and gave the rest to his nephews… (Minet 1987:84).

Based on other contemporary accounts of the journey, it is clear that Minet was not alone in his assessment of La Salle's officers and would be soldiers.

Problems and distractions beset La Salle from the onset and soon members of the expedition began to question La Salle's ability to direct and organize a project of this magnitude. They also began to question his state of mental health. Anyone foolish enough to express a difference in sentiment or opinion risked a major confrontation with the ever mercurial La Salle. La Salle reticent and completely unapproachable, suspected everyone of conspiring against him.

Considering the strategic importance of the mission La Salle was about to undertake, maintaining a degree of secrecy seemed only prudent. However, the man who helped to engineer treaties between entire nations of Native Americans in the name of France and her king; seemed to have lost all capacity for tact and diplomacy among his own men (Lockridge 1931:182-193; Parkman 1963:214-215; Osler 1967:53-54; Balesi 1992:55). La Salle's abrasive personality would put him at odds with nearly everyone involved in the planning and execution of 'his' mission to the New World (Weddle 2001:110).

The working relationship between La Salle and Beaujeu, the captain of *Le Joly*, would become strained immediately following their first meeting in Paris. As preparations for the expedition got underway in La Rochelle, La Salle's secretive and somewhat guarded manner nettled the veteran warrior to no end. Confused and confounded at every turn in his dealings with La Salle, Beaujeu began to express a dissatisfaction and resentment toward La Salle. In several letters to the Marquis de Seignelay, Minister of the Navy, and his associate Cabart de Villermont, Beaujeu complained vehemently of the treatment he received at the hands of La Salle.

Many of the accusations exchanged between La Salle and Beaujeu were contemptibly trivial, however many of Beaujeu's concerns were not unfounded. Beaujeu was not pleased with the course of events leading up to their departure, emphatically expressing his views that La Salle was in no way qualified to lead such a mission. The thirty year military veteran understood, perhaps better than anyone that the tiny fleet and the inhabitants of the would-be French colony would soon be entering the territory of an eminently hostile enemy.

The Spanish crown and colonists controlled an extensive territory rich in natural resources. Throughout most of the 17th century, New Spain languished. Spain, itself in economic collapse, could provide little help, yet New Spain would remain the crown jewel of a vast colonial empire for decades to come. Spain would meet any foreign threat with all of the military resources at her disposal in the New World (Gerhard 1982; Holmes 1982:106-128; Weddle 1985, 1991; Taylor 2001:67-90; Bruseth 2005:19). This is the situation that awaited La Salle and nearly three hundred soldiers, sailors and colonists.

Though Beaujeu may have questioned La Salle's state of mind on several occasions, he may have been more concerned with his limited military background:

> You have ordered me Monseigneur (Seignelay), to give all possible aid to this undertaking, and I shall do so to the best of my power; but permit me to take great credit to myself, for I find it very hard to submit to the orders of the Sieur de la Salle, whom I believe to be a man of merit, but has no experience of war except with savages, and who has no rank, while I have been captain of a ship thirteen years, and have served thirty by sea and land (Parkman 1963:259).

Given La Salle's penchant for keeping his own council, it is not surprising that he would refuse to share the command with Beaujeu or anyone else (Weddle 2001:105, 111-112). What is so remarkable as to elicit disbelief was the inability of the king and his ministers to fully comprehend the military bearing of this mission, and their insistence that La Salle retain sole command of the entire operation (Parkman 1902:264). What should have been strictly a military undertaking became a remarkable attempt to establish a colony deep in enemy territory. Robert Weddle (2001:104) aptly states that Louis XIV's "mistake lay in his refusal to heed Beaujeu's warnings."

In all fairness, La Salle after spending nearly fifteen years in the woodlands of New France trapping and exploring, developed all of the necessary skills required to survive in the harsh backdrop of Canada and the American Midwest (Muhlstein 1994:18-34). The tenacious Norman's ability to survive in the wilderness became near legendary (Lockridge 1931:140-149). La Salle undoubtedly proved himself a competent leader of men during several major forays into the North American wilds, culminating with the exploration of the Mississippi River and several adjoining tributaries. La Salle, an accomplished *voyageur* was the only member of the Gulf expedition with any true knowledge of woodland survival. In lieu of Beajeu's concerns, La Salle's familiarity with wilderness survival tactics and his experience treating with Native Americans, combined with Beajeu's thirty-plus years of military service should have provided the expedition with strong and resourceful leadership (Weddle 2001:84).

La Salle's Army

Logistics was hardly yet a science in the late 17th century (Lynn 1993:103-104). Even under optimal conditions, the coordination of efforts, implementation of organizational plans, and the procurement of equipment and supplies for an enterprise as far-reaching as La Salle's would have proven a daunting task. Robert Weddle (2001: 104) was correct in his assessment of the explorer when he stated "La Salle was out of his element in trying to organize an expedition of such scope."

Despite the many criticisms aimed at La Salle for his apparent lack of logistical skills, in terms of material value, the Frenchman organized and launched the costliest voyage of settlement to date. Difficulties and distractions that seemed incapable of being negotiated or overcome, presented themselves to La Salle at every turn, yet somehow he managed to secure the services of four ships, and all of the necessary equipment, supplies, trade goods, and weapons needed to establish a solid French foothold in the Gulf of Mexico. In the end, it was not the lack of sufficient stores or proper equipment that would prove so costly to La Salle and his dreams of settlement.

As preparations for the expedition continued, one of La Salle's major concerns should have been the selection of those qualified personal who would accompany him to the gulf. The king granted La Salle the leave to recruit one hundred soldiers at royal expense (Bruseth 2005:20). The task of recruiting the needed men was left to the junior officers and cadets under Captain Beaujeu's command, who were less concerned with finding suitably qualified candidates for the voyage, then fulfilling their quotas (Weddle 2001:106). Though contemporary accounts of La Salle's journey to the Gulf of Mexico diverge on many points, they are of a consensus that most of the soldiers and skilled laborers hired by La Salle and his associates were of a less-then reliable sort.

Prior to the departure of the fleet from Rochefort, issues concerning departure delays and the unprofessional bearing of the hired soldiers were brought to the attention of the Marquis de Seignelay:

> His Majesty awaits with impatience news of the ship's departure. It is important that she make sail quickly. [The king] finds that the orders

> he gave on this subject have not been carried out with dispatch, especially regarding the raising of soldiers. They write to him that they are scarcely more than children, or men little suited for service [emphasis in original] (Weddle 2001:114).

When questioned by Arnoul on the condition of the newly acquired troops, Beaujeu emphatically replied:

> I swear to you, Monseigneur, that, for new recruits, I have never seen better troops. True, there were some young men, but they were strong and would acclimate more readily than older ones (Weddle 2001:115).

In his account of the La Salle expedition, Father Chrétien Le Clercq glibly referred to the hired troops as, "mere wretched beggars soliciting alms, many too deformed and unable to fire a musket" (Charlevoix 1962:62; Cox 1973:209). Henri Joutel, La Salle's second in command, was an experienced and highly disciplined soldier having served in the French army for nearly seventeen years. Following their first foray ashore after reaching the Gulf, the ever professional Joutel records this critical appraisal of the raw recruits:

> Truthfully, although we had 120 to 130 men with us, 30 good men would have been better….these were all men who had been taken by force or deceit. In a way, it was almost like Noah's Ark where they were all sorts of animals. We likewise had men of different nationalities.

> The soldiers had been recruited by the lower ranking officers of the Navy, who received a half *pistole* for each man, by whatever means possible (Foster 1998:85).

La Salle was a man possessed by a contradictory nature. He was a living paradox capable of exact, valid, and rational reasoning one moment; only to discard any vestige of common-sense or logic the next. La Salle's knowledge and experience was a deep well that at times, he simply refused to draw from. This becomes most apparent in La Salle's first *Memoir*, where he attempts to rationalize his decision not to take regular troops on the expedition to the Gulf of Mexico:

> The Sieur La Salle does not ask for regular troops. He prefers the assistance of persons of different trades, … because they will become soldiers when it may be necessary for them to be so (Cox 1973:181-182).

The engineer Minet was quick to point out that not one of the officers in charge of La Salle's troops, with the exception of Joutel, had any real military experience. La Salle was aware of his officer's limited experience, though he did not see this as detrimental to the outcome of the expedition. He tersely explains away Minet's observation:

> In enterprises of this kind success depends more on the experience of the commander than on the bravery of those who have only to obey, as was shown in what was done by those who previously accompanied the Sieur de la

> Salle, the greater part of whom had not seen service (Cox 1973:182).

Two of the officers, Gabriel Barbier and Colin Crevel de Moranget (La Salle's nephew) had accompanied La Salle on his 1682 exploration of the Mississippi River. Nicolas de La Salle and the two Récollet priests, Membré and Douay were also members of the 1682 expedition (La Salle 2003).

La Salle perceptively makes note of the unconventional style of warfare conducted in the New World, especially against Native American adversaries. Over the decades; French, British and Spanish colonial armies and militia had been gaining experience of a new kind in colonial warfare (Starkey 1998; Nester 2000:1-53). Native Americans did not fight according to the formal rules of continental European warfare. Native Americans would fight only intermittently, and considered everyone, including women and children, viable targets open to attack (Malone 1991). His solution was simply to rely on the men who accompanied him down the Mississippi in 1682:

> Those whom the Sieur de la Salle has in the country accustomed to such expeditions, will be sufficient to sustain the rest and to render them capable of any enterprise whatever (Cox 1973:182).

The wayward nature of professional soldiers, the potential for "debauch and license," and the perceived added expense of using regular troops and their officers, made them in La Salle's humble opinion, far more trouble than their worth. What experience or contact La Salle may have had with regular troops, whether in France or during his tenure in New France is unknown.

The reasoning behind La Salle's apparent disdain for regular professional troops is unclear. The men signed by La Salle's agents were hardly soldiers in the professional sense; almost completely lacking in military discipline and training.

Summation: Beginning of the End

Throughout the 17th century, recruiting men for a mission overseas was never an easy task (Balesi 1992:37; Johnson 2002:206). Skilled craftsmen and labor were particularly averse to uprooting from their homes in France to take up residence in His Majesty's colonies in North America. The king had been most generous in fulfilling most of La Salle's requests for the necessary equipment, stores, and materials needed to complete his mission. Would have securing a detachment of professional soldiers been out of the question? Certainly the funds were provided to hire troops for the perilous journey.

Much, if not all of the blame for the failure of the expedition to the Gulf of Mexico has been placed squarely on the shoulders of La Salle. Reasons for La Salle's inability to locate the Mississippi delta have been the subject of much debate among historians (Bolton 1915; Wood 1984; Weddle 1987:7; Morris 2004:28-41). Even if La Salle had located the mouth of the Mississippi, reaching his intended destination, it is highly unlikely that the French colony would have survived overly long. La Salle's first order of business should have been to secure the region and begin construction of a defensible fortified emplacement. Without a sizable, well trained body of troops and support personal, this would have proven an impossible task.

The lists of required stores and equipment submitted by La Salle in his two *Memoirs,* include a substantial number of weapons; including cannon, small-arms, sufficient powder and ammunition, and various edged-weapons (Cox 1973:186-188; Falconer 1975:16-17; Weddle 2001:98). Small arms discovered on *La Belle* included a quantity of flintlock muskets. Considering that the flintlock musket, which would eventually supplant the matchlock, did not become the standard issue firearm of the regular French Army until the early 18th century, it was astonishing to find these firearms among the weapons stores of *La Belle*. Such weapons in the hands of even a small group of well-trained disciplined soldiers could provide the backbone of a formidable fighting force; a point that an exasperated Henri Joutel would make repeatedly in his journal.

The colonization of New France involved a simple series of steps: exploration, conquest, and colonization. Generous support from Louis gained La Salle the ships and materials he needed to make the long voyage. It was left to La Salle to recruit the workers, craftsmen, and soldiers he needed to facilitate his mission. In the end, it would have been prudent for La Salle to reassess his military strengths and weaknesses, based on his own experiences and knowledge of the New World. Instead, La Salle would bring a number of untried men, women, and children into a region of which his knowledge was extremely limited.

CHAPTER III

THE SWORD

History and Archaeology of the Sword

A sword is a relatively simple construct consisting of a blade and a hilt. A typical sword hilt is comprised of a pommel, handle or grip, and a simple or complex hand guard (Figure 1). A glossary of hilt, blade, and scabbard terms is provided in the appendices (Appendix B). There are four main classifications of swords based on blade type; 1. straight cutting blades sharp on one or both edges; 2. straight, narrow rigid blades used exclusively for thrusting; 3. curved blades usually sharp on the convex edge used for cutting; 4. re-curved blades with a single edge, which widens near the point of percussion. The width, length, and shape of the blade determine the type of sword being wielded.

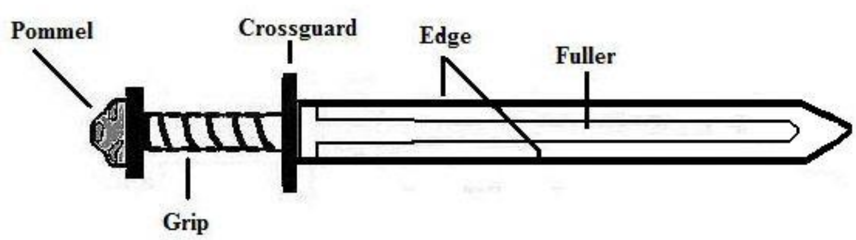

Figure 1. A typical 11th-century, Anglo-Saxon sword. *Illustration by J. Kampfl*.

Early bronze swords were cast in one piece from a stone mold. These swords had two-edged, leaf shaped blades designed primarily for cutting. Late in the 10th century B.C., iron forged swords appeared in central Europe (Harding 2007). These early iron swords retained the same basic form of the bronze swords, but were heavier and slightly longer. The iron blades had two cutting edges, tapering slightly to an obtuse point, and dealt a forceful slashing attack (Cowen 1951:195-214; Harding 1993:8-19; Schwarzer 1986:2-50).

By the early 10th century A.D., improved forging techniques made it possible to fabricate stronger blades. The iron blade was now fabricated by repeated firing and hammering, a process that converted the iron into mild steel by the addition of a small amount of carbon. Sword blades were also made of laminated strips of iron, which were forged together. A stronger, more rigid blade with reinforced cross-sections, could now be tapered to a finer, sharper point, producing a sword capable of delivering a lethal thrust. From this point in time, thrusting blades were developed alongside the broader, two-edged blades. Single-edged straight swords were uncommon in Europe before the 16th century, but thereafter became quite popular with the military in the forms of the backsword and light spadroon, a military sword possessing a blade designed for both a cut and thrust attack. Most of these blades have a shallow fuller running along each face, reducing the weight of the blade without weakening it (Skillings 2004:67-70).

The European sword of the early Medieval Period consisted of a double-edged blade with a single fuller. Riveted to the tang of the blade was a hilt constructed out of wood, bone or ivory wrapped with smaller strips of leather or wire braiding to improve the grip (Oakeshott 1991:17-21; Peirce 2007:10-15). By the 11th century, a crossguard or a pair of quillons was added to the hilt providing added protection for the hand (Davidson 1998:51-52).

The history of arms and armor is a history of development and counter-development. The designs and styles of body armor changed over time to provide more protection to the wearer. By the early 14th century, composite (mail and plate) armor made its way onto the battlefield, and by the latter part of the century, combatants were fully encased in plate armor. Plate armor offered a great deal of protection against a cutting or slashing attack, but was not without its weaknesses. A heavy or bludgeoning blow could seriously damage plate armor, causing injury to the wearer, and despite the nearly impregnable appearance of plate armor, there were still parts of the body exposed to attack. A heavily padded coat was worn beneath the plate armor as added protection. This coat was reinforced with chain mail where body joints were not adequately protected by the plate armor.

The tuck (French *estoc*, “thrust”) was a sword designed to penetrate or pierce the vulnerable joints of plate-wearing combatants. By the 17th century, the tuck along with the saber, was used extensively by cavalry units in east Europe. Another advantage of a sword designed to thrust, is that a thrust is more difficult to parry than the cut and tends to be more lethal. The small sword of the late seventeenth and eighteenth centuries was a purely thrusting weapon (Hoffmeyer 1979:52-79).

The Japanese had been using curved, single-edged swords since the early 7th century (Satō 1983:170-173). Similar blades were also developed, apparently independently, during the 9th century in the area between the Caucasus and Carpathian Mountains. These swords differ from Japanese swords in that they possess a sharp step in the spine and a sharpened forward section of the blade (*chamfer*). By the mid-14th century, this type of sword was replacing straight two-edged blades throughout the Middle East.

The Persian sword (*shamshir*) became increasingly curved during the sixteenth and seventeenth centuries, and the chamfer disappeared entirely. This type of blade was introduced by the Moguls from Persia into India, where it was imitated by native blade smiths (Egerton 2002). From the 16th century, swords with curved blades began to be used more frequently in Western Europe, particularly for light cavalry forces. During the 18th century, a heavier curved blade was also adopted in India, possibly because of European influence. The expansion and empire building of the 19th century again exposed European armies to the heavily curved Oriental swords. During the 19th century, attempts were made by western armies to improve the curved blade so that it could also be used for thrusting. One idea was the addition of a stiff rib down the spine as the blade was forged. This attempt was unsuccessful, however, and resulted only in reducing the capacity of the blade to cut (Gordon 1958:22-27).

The most crucial phase of sword construction is the joining of the hilt to the blade. The tang is the unsharpened end of the sword that fits into the grip. The taper, width and thickness of the tang, depends on the specific sword design. There are five main types of grip-tang combinations. The first type of blade is simply fixed to the forward edges of the grip by transverse rivets, as on early Bronze Age weapons. The second type of hilt assembly consists of the tang, which is forged or cast to the outline of the grip, and plates of some material, such as wood, horn, or ivory, are riveted onto each face of it. An example of this type of hilt combination is the Persian *shamshir*.

In another technique, the narrow tang is passed through the guard and the grip, and is then peened over on top of the pommel to hold the entire hilt assembly together. This method is used most frequently on European swords, especially the small sword. The pommel cap of this type of sword may even be threaded, the entire hilt assembly being secured by merely screwing the pommel cap to the tip of the tang. The hilt assembly of most Japanese swords consists of a flat tang, a guard, and a grip. The tang passes through the guard and is secured within the grip by a transverse wooden peg. The final method of joining hilt and blade is by simply cementing the tang into a one-piece metal hilt, as on many Indian swords.

The Rapier

The evidence for what was meant by the word rapier at a specific period is very limited. In the late 15th and early 16th centuries, the term most likely referred to a sword, as opposed to an arming sword or saber, used to accessorize civilian dress. As the edged weapon historian Egerton Castle writes:

> The etymology of the word *rapier* is obscure. Some derive it from the German *rappen*, or *raffen*, to tear out. Others connect it, through *raspière*, to the Spanish *raspar* to scrape or scratch. Mercutio, stabbed with a rapier, exclaims about "a cat, a dog, to *scratch* a man to death." Others, again, will see in it a derivation of ραπίς, a rod. We incline towards the German etymology, were it only for the reason that the word *rappier* occurs in some of the earliest German printed books. *Rappier* in German must have been a slang word (the rapper, or beater, akin to our own word rap, to strike) soon adopted as a technical one. The word does not occur in Spanish or Italian works, and in France the word *rapière* (except from the pen of modern novelists) always was applied somewhat contemptuously to swords of portentous lengths, of outrageous and outlandish fashion" (Castle 1910:329).

Other scholars of the sword suggest that the word rapier first evolved from the Spanish *espada ropera*, meaning robe sword or the sword worn in civilian dress. This styling appears in the *Relaciôn de los inventarios que se ficieron en los bienes muebles que tenia el duque don Alvaro de Zúñiga* of 1468, *"Otra espada ropera, dorada y avirada"* (Blair 1962:7). The phrase reappears as early as 1503 in the *Inventario que hizo por mandado de la Reina Católica de todas* *las cosas que se hallan en los Alcázares de Segovia, "Una espada rropera de la onça partida, é tiene en cabo de la canal una* m *è una y: la mançana é la cruz de hierro dorado viejo, è tiene en la mançana de ámas partes, un esmaltico con las armas de Luna"* (Leguina 1912:121, 438). Regardless, the first Spanish reference predates the earliest French form of the phrase, which first appears in 1474: *"Icellui donna au suppliant de la dite espee rapiere sur la teste"* (Gay 1887:287). The French rapier is first referenced in 1488, *"Garni de deux bracquemars et d'une espee rappiere"* (Godefroy 1889:598).

The sword underwent significant changes in Europe during the early 16th century, and proliferated in a variety of forms. Many of these changes occur during the period when defensive armor, such as the metal gauntlet, fell into disuse. Until the first half of the 16th century, the sword hilt consisted of a pommel, grip, and a simple crossbar or *quillon*, which protected the sword wielder's hand. The technique of passing the right or left forefinger over the quillon was developed at some point, providing much greater control of the weapon. In order to protect the exposed finger, a metal ring was placed in front of the crossguard or quillon.

The obvious next step was to place a corresponding half ring on the opposite side of the blade, possibly for the sake of symmetry. This change in hilt design apparently developed before the 15th century, first in Spain and then later in Italy. From the two side-rings, the protection of the hand was further improved by the addition of a knucklebow (Valentine 1968:10-11).

The knucklebow is a semicircular bar extending from the quillon towards the pommel. Eventually a series of rings would be added to the hilt to provide further protection for the hand, both in the vertical and horizontal planes. By the mid-17th century, Spanish dueling rapiers had developed a cup guard, which completely enveloped the hand. By the middle of the 16th century, the rapier had developed into a clearly distinct sword type, with a long, narrow blade, and with the hand now protected by a series of guards and counterguards (Wagner 1967:31-33). Swords with slightly more complex hilt arrangements first appeared about the mid-14th century. Metal bars were added to the sword hilt, extending out from the cross-guard and offering better protection for the hand (Figure 2). Hilts of 16th and 17th-century rapiers offer the best example of how complex guard and quillon configurations developed. Eventually the complex hilt of the rapier gave way to the modest yet functional counter-guard and knucklebow of the small sword (Valentine 1968). Rapier hilts took many forms, often ornately decorated with precious metals, extremely intricate metalwork, damascening, and enameling.

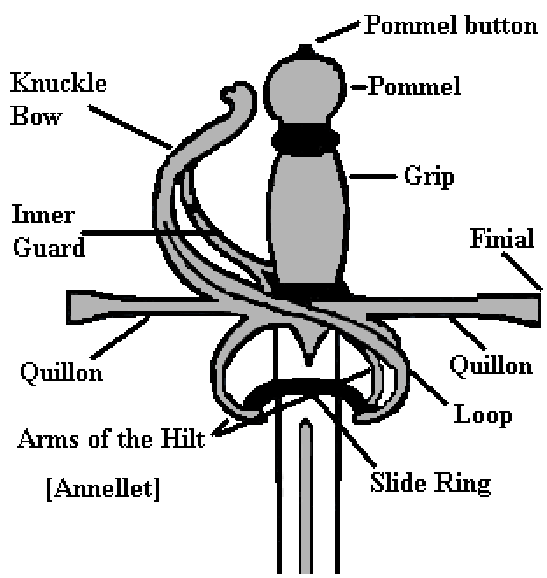

Figure 2. Hilt arrangement of a 17th-century rapier. *Illustration by J. Kampfl.*

A.V.B. Norman's classification system of the rapier and small sword is based entirely on the changing elements of the hilt and hilt design. As it was extremely common for older blades to be remounted with a different hilt, Norman chose to ignore the dates on blades when considering the date of the hilt. Norman also relies quite heavily on contemporary paintings, especially portraits, to date specific rapier and small sword hilts (Norman 1980). The blade of any given sword is rarely visible in a portrait making the identification of the blade almost impossible, and prevents attempts to date the blade accurately.

The inherent problem with Norman's classification system is that it discounts the blade entirely, suggesting that the hilt configuration alone is what determines the type of any given sword. In truth, a rapier-style (compound) hilt could be fitted with a number of different blade types. Many scholars argue that a sword type is defined by its blade cross-section and geometry, *i.e.* a straight cutting blade, cut-thrust blade, purely thrusting blade, or a curved cutting blade with sharp point, and not its hilt configuration (Oakeshott 1997:21-23).

Blade smiths were constantly experimenting with new blade designs, consistent in their attempts to design a blade that was strong, yet light and flexible. The diversity of rapier blades is considerable. They may vary in length, thickness, and cross-section. They ranged from flatter, tapering blades to blades possessing a much thicker cross-section, narrowing towards the point. Most rapier blades are rigid, extremely narrow, and become much thinner toward the point (Wagner 2004:13). It is not uncommon for a rapier blade to become oval or even round, in cross-section as it nears the point. The weight of a rapier was concentrated in the hilt, thereby facilitating an agile point to make rapid long-reaching stabbing attacks.

Rapier blades are comparatively thin but have thick cross-sections. Blade cross-sections vary from flat diamond or triangular shapes capable of holding a defined edge, too much thicker octagonal or hexagonal cross-sections with virtually no edge. Blade smiths of the Middle-Ages developed the fuller, a center groove running the length of the blade (Underwood 1999:48). This reduced the weight of the blade without significantly reducing its strength. Similarly, the various cross-section types reflect the efforts of cutlers to produce a light yet rigid blade, which would be ideal for the thrust.

Most rapier blades were produced in highly specialized workshops located in major European cities such as Milan and Brescia in Italy, Toledo, and Valencia in Spain, and Solingen and Oassau in Germany (Gaibi 1965:332-352). From these cities, the blades would be exported throughout Europe and mounted in accordance with local fashions. Authentic blades bear the stamp or signature of the maker, his town, and the stamp of the city guild (Gardner 1963:333-375).

Rapier Fencing and Instruction

The military and weapons training received by 17th-century French troops, and the specialized training received by colonial French troops, was briefly discussed in chapter two. Archaeological and historical evidence confirms the fact that La Salle's troops were armed with both flintlock and sword. A thorough discussion of the history of fencing is beyond the scope of this dissertation; however a brief explanation of the distinction between civilian and military applications of the sword is necessary (Gaugler 1997).

By the end of the 17th century, gunpowder weapons had supplanted swords and other edged weapons on the battlefields of Europe and North America, yet edged weapons, especially the sword, remained as important secondary weapons (Peterson 1956; Neuman 1967:216-217; May 1970:12-19). Flintlock muskets such as those discovered on *Belle,* were technologically superior to the older matchlock or wheel lock weapons, yet even flintlocks would prove notoriously unreliable at times. Improper loading, wet powder, lack of proper ammunition or spare gun parts, and overall mechanical unreliability, were all problems that plagued the armies of the 17th century. Despite the growing dependence on gunpowder weaponry, the armies and navies of Europe would issue swords to their soldiers, sailors, and officers well into the 19th century.

Though armed with a sword, the soldiers and sailors of the 17th century were not necessarily instructed in its use. The troops under LaSalle's command would have received little if any practical training in the use of the sword, especially in combat situations. Common soldiers were not trained in swordplay to any extent as officers who were usually ranking members of the aristocracy, and could afford to attend fencing schools or even hire a well-established sword master for private instruction.

Treatises and instruction in other martial arts forms such as wrestling, boxing, the use of various pole weapons, and cavalry combat were being published from at least the late 13th century. Fechtbüch Ms. I-33, written by an un-known German author during the late 13th, early 14th century, is arguably the oldest treatise on Western swordsmanship on record (Forgeng 2003). The Ms. I-33 fechtbüch is also the earliest known evidence for the use of the sword for personal self-defense, though the Ms. I-33 makes little, if any distinction between civilian and military swordsmanship. Sword combat was taught with the sword alone, or in conjunction with another weapon; buckler, shield, dagger, etc. (Mazo 1696).

With the exception of Spain and Portugal, the habit of carrying a sword while in civilian attire was not universal in the middle ages, but it later became the custom of every gentleman to carry a rapier in civil life, and as a consequence dueling increased. Previously dueling took the form of judicial combats, conducted with strict formality Dueling with a rapier rapidly encouraged the art of fencing (Castle 1910; Kiernan 1988:91; Billacois 1990; McAleer 1994; Hutton 2002:63-73).

As the rapier evolved and dueling became popular in the 16th century, fencing manuals and treatises were written and published in astonishing numbers. Perhaps the earliest known treatise describing the Italian school was Fiori dei Liberi's *Flos Duellatorum in Armis*, written in 1410 (Anglo 2000:326). In 1553, the celebrated Italian fencing master, Camillo Agrippa, published *Trattato di Scientia d'Arme* (Agrippa 2009). This innovative text was the first to emphasize the thrust over the cut when engaged in rapier combat.

The Italians masters were unsurpassed in their method and approach to rapier fencing. Salvatore Fabris, the consummate fencing master, was renowned for his skill with the blade. In 1606, Fabris published *De lo Schermo ovvero Scienza d'Armi*. This early treatise was one of the most detailed and comprehensive ever written; taking a systematic approach to teaching the art of rapier fencing (Fabris 2004). Building on the works of Fabris were other Italian masters. Ridolfo Capoferro's (1610) well-illustrated *Gran Simulacro dell'Arte e dell'Uso della Scherma* (Leoni 2011), Francesco Alfieri's (1640), and *Regole della Scherma* by Francesco Antonio Marcelli (1686), epitomized the sword master's art.

The system of Italian rapier technique in the 17th century was based primarily on the teachings of Francesco Alfieri. Alfieri's treatise *L'Arte dib en Maneggiare La Spada* (1640) demonstrates the basic guard positions of the rapier, along with the use of the rapier with dagger and cloak. Alessandro Senesio (1660), and Bondi Di Mazo (1696) all published treatises on the use of sword and rapier (Karcher 2010:61). The fencing manual of Giuseppe Moriscato Pallavicini (1670), *La Scherma Illustrata*, was a superb, heavily illustrated text demonstrating the use of the rapier in attack and counterattack (Cohen 2002:27).

The Spanish school of fence *La Verdadera Destreza*, or "The True Skill," developed slightly later than the Italian. The first noteworthy treatise published in Spain on the use of close-in weapons was *Libro de Hieronimo de Caranca, natvral de Sevilla, que trata de la philosophia de las armas y de su destreza y de la aggression y dfension Christiana*, by Spanish master Jerónimo Sánchez de Carranza (Carranza 1582). Another contribution to the early Spanish school was *Nueva ciencia y filosofia de la destreza de las armas, su teoria y su practica*, by Luis Pacheco de Narváez (Pacheco 1672). The Italian and Spanish schools developed into two distinct systems of fence, each advocating different styles of swordplay, offering instruction in the use of the sword alone or in combination with other weapons (Anglo 2000:9-12, 40). In 1628, Spanish master Girard Thibault completed his work *Académie de l'Ȇspée*, which is widely considered to be one of the best illustrated fencing manuals ever produced (Thibault 2006).

Fencing publications and treatises on sword fighting began to focus on tactics and systems designed for individual combat as opposed to military action as seen on the battlefield. The teaching methods, selection of technique, style of performance, and underlying concepts varied according to the type of sword being used and the instructor or master. Each master advocated his own particular school of fence; special training systems, the correct way to grip a hilt, appropriate footwork, and the various techniques of offense and defense. Even in a single specialized branch of fencing, differences in style, technique, attitudes, and objectives existed. By the early 15th century, the Italian and Spanish masters, along with their German counter-parts, began to develop their own schools of weapons instruction and theory.

Under the Italian and Spanish masters rapier fencing reached its zenith in the 17th century, which by this time was widely viewed as a scientific, even artistic form of martial arts training. Building on the Spanish *Destreza* tradition; Alvaro Guerra de la Vega's *Comprension de la Destreza*, published in 1681, and Nicolas D. Tamariz's 1696 work *Cartilla y Luz en la Verdadera Destreza*, are two superlative examples of how rapier combat would develop into a highly technical and theoretical system of swordsmanship (Vega 1895; Tamariz 1902). The writing and publication of fencing treatises was not restricted to Italian and Spanish masters alone. A growing corpus of literature was being produced by other European swordsmen. Every nation boasted a number of self-proclaimed masters offering a wide range of instruction on various weapons, fighting styles, and techniques.

In 1614 English fencer George Hale published *The Private School of Defense*, in which he was critical of the impractical methods of fence taught by most sword masters of the period, though Hale states that "The Science of Defence is an Art Geometricall," a clear reference to the already well-established Italian and Spanish schools of fence (Aylward 1956: 90-91). Joseph Swetnam (1617), published *The Schoole of the Noble and Worthy Science of Defence*, and like Hale his instruction was grounded primarily in the theoretical fencing systems established by the earlier Italian and Spanish masters, advocating the thrust over cutting blows (Wise 1974; Evangelista 1995:70, 235). Swetnam, like many English sword masters, offered instruction on a variety of other close-in weapons, even going so far as to suggest that his techniques and system of fence would develop the skills of the military man on the open battlefield, as well as the civilian duelist.

By the 17th century, fencing had become an indispensable part of every cultivated gentleman's education. Possessing some skill and knowledge of the *scienza cavalleresia*, or 'gentleman's craft' as it was often referred to would begin to serve an aspiring gentry as a necessary quality for social preferment, not only as a means of "defending their honor" (Cohen 2002:25). Personnel self-defense and dueling, guided the development of the art of fence from at least the 17th century on. The attitude and techniques that are necessary to these ends differ in many ways from those of military swordsmanship. This distinction is of no small importance; as not all sword masters advocated this type of martial arts training.

The Italian fencing Master Giacomo di Grassi published his seminal work *Ragione di adoprar sicuramente l'Arme, si da offesa come da difesa*, in 1570. The popular treatise was translated into English in 1594, and published under the title *Giacomo Di Grassi, His True Arte of Defence*. Di Grassi's treatise focused on a number of different weapons, his training methods geared towards developing the skills of the soldier. Di Grassi makes the distinction between military combatant and civilian duelist when he writes:

> The soldier differeth from other men, not because he is more skilful in handling the sword or javelyn, but for that he is expert in everie occasion to know the best advantage & with judgement both to defend himself with anie thing whatsoever, and therewithal safely to offend the enemy: In which & no other thing consisteth true skirmishing (Di Grassi 1594:43).

A contemporary of di Grassi, the English sword master George Silver viewed sword combat as a practical military art (Cohen 2002:32-33; Wagner 2004). In his highly influential work *Paradoxes of Defense*, Silver completely dismissed the Italian school of rapier fencing, as little more than "Schoole trickes and jugling gambolds" (Silver 1599:2). Silver argued that the rapier was an impractical weapon on the battlefield, advocating the more traditional style of English weapons and military training. There was little time for the planned, almost choreographed strategies of attack, defense, and counterattack utilized in civilian fencing (McAsh 1996:97-99).

The practiced metered exchange found in fencing would hardly be possible on the chaotic battlefield. Silver's arguments had little effect as the rapier and rapier fencing gained rapidly in popularity among the English gentry.

Small Sword

By the 1630s, a new style of fencing was quickly developing in France. Relying on speed, precision, and subtle wrist movements, it required a sword that was both lighter and shorter in the blade than the traditional rapier. The small sword was a transitional weapon, most likely evolving from the rapier and light rapier during the next few decades (Norman 1967:1; North 1982; Wilkinson-Latham 1977:22-23). By the 1660s, the conventional form of the small sword had been established, remaining nearly unchanged for the next two centuries.

The small sword quickly became the preferred weapon of fencing masters across much of Europe. In the hands of a skilled combatant, the lightweight small sword was a deadly weapon capable of inflicting great bodily harm. A sword was first and foremost a weapon of war, although its design and form were often influenced by the dictates of fashion or aesthetic preferences. The metalwork and decoration of nearly every sword type became more elaborate over the centuries (Byam 2003; Grancsay 1986). Most of these highly ornate swords were generally not battle-ready, often displayed as ceremonial weapons during formal occasions.

On small swords made before 1700, the arms of the hilt are quite large, and the knuckle bow is usually straight, often with a central feature such as an indented molding or figurative design. Pommels could be globular, pear-shaped, or sometimes facetted. The ornamentation varied enormously from workshop to workshop, with both figurative and abstract designs being popular. Bold chiseled relief ornamentation was still fashionable on Dutch and German hilts of the 17th-century; pierced lace-work steel, with small chiseled panels set at intervals on the hilt, was fashionable in Northern Italy towards the end of the century. Some distinction should be made between the light decorative small swords worn with civilian attire or during ceremonial occasions, and the heavier, more solidly constructed weapons actually used in combat (Moore 1968:125-126; North 1993a:68-69).

Until the mid-18th century, hilts in general were made of iron with brass and silver being the most frequently used alternate metals. Iron was a stronger metal and hilts manufactured from this material could be covered in silver or decoratively inlayed with brass or silver (Mazansky 2005:21). Before 1660, most military hilts were of iron, but by the last quarter of the century, brass increasingly began to be used because it was less expensive (North 1993b:76). Consequently, many of the military forms of small sword were made of cast brass, though sometimes gilded or silvered. Military swords dating from the late 17th century to the early part of the 18th century are often very plain, and the shells have substantial raised rims.

Various features such as the shape and size of the pommel, larger arms of the hilt, and the form of the guard suggest a more robust weapon. Most hilts such as these are fitted with plain, very workmanlike blades, and would have been ideal for self-defense. At their best, brass-hilted military swords were well made and very serviceable. At their worst, they were crudely made and weak. One feature that distinguishes a small sword from a rapier is the length of the blade. Early small swords are usually fitted with narrow rapier blades that have been considerably shortened, or with the light double-edged blades supplied by Solingen cutlers (Weyersberg 1926). In about 1660, a new type of blade was introduced, almost certainly from Germany. This had a hollow-ground triangular section, combining strength with lightness. The earliest examples of this type of blade were clearly intended to be used for cutting as well as thrusting, and have very wide edges, especially at the forte, the bottom one-third of the blade. However, the edges were usually very weak and tended to crack and split.

By the early 1700s, the blades had become much narrower and were designed solely for thrusting. Although these blades are usually quite wide at the forte they taper sharply, giving strength where it was needed for parrying an opponent's blade. A type of blade known as a *colichemarde* became fashionable from about 1675 on, and had a wide forte that tapered very suddenly to a narrow thrusting point. Many small swords of the early-18th century were fitted with rapier blades from the mid-17th century, that were cut down, reground, and trimmed to fit new hilts (Oakeshott 2000:251-252).

For the blacksmith or metal artisan, technical knowledge and experience in working their trade raised and improved sword quality, and the finely wrought sword hilts and blades of the 17th and 18th-centuries attested to their skill. Ironically, by the mid-to late 17th century brass hilt components were being produced in greater numbers. The brass hilt components and other sword related fittings could be produced in larger quantities and at reduced costs by simply casting each component in a separate mold. Each of the cast pieces could then be assembled, or reassembled, by brazing them together. Brazing is a method of joining metal parts together by melting or fusing a thin layer of brass between the adjoining surfaces. The brass is then heated to melting temperature (450 ◦C) and a flux is used to prevent oxidation (Simonson 1969; Yates 1992).

Swordsmiths who worked in iron and steel were appalled at the notion of peddling these crudely cast brass-hilted military swords, believing that this method of production would lead to a decline in standards of workmanship and reflect poorly upon their craft (North 1993b).

Undoubtedly, many of the brass hilts cast during this early attempt at mass production were poorly constructed and incapable of being used for prolonged periods. There are innumerable surviving examples of brass hilts in museums, along with the brass hilt components from *La Belle*, which appear quite solid and very serviceable, an indication that not all cast-metal hilts were of poor quality.

Sword Component Terminology

In order to understand these weapons, their construction, and use, it is necessary to define them accurately within the context of how they were viewed by their contemporaries. In many historical sources the same name often applies to different weapons, according to the country of origin (Martin 1967:192-193). The names applied to the various parts of a sword were likewise imprecise, according to the period or country of the original source. With these limitations in mind, glossaries, lexicons, encyclopedias, and treatises are an indispensable source of knowledge for identifying sword types and components (Appendix B-C).

Throughout the seventeen and eighteen centuries, English dictionaries and fighting manuals made little distinction between rapiers and small swords. In William Hope's *Scots Fencing Master or Compleat Small-Sword Man*, the term small sword and rapier are interchangeable throughout the text (Hope 1687:158). In *A New, Short, and Easy Method of Fencing: or the Art of the Broad and Small-Sword Rectified and Compendiz'd*, Hope again uses the terms rapier and small sword indiscriminately (Hope 1707:60). The 1771 edition of the *Encylopædia Britannica*, defines a rapier as a "formerly signified, long old fashioned broad sword, such as those worn by common soldiers: but it now denotes a small sword, as contradistinguished from a back-sword."

In his *Thresor de la langue françoyse, tant ancienne que moderne,* Jean Nicot (1606:255) defines the *espée* as a long sword (*longue espée*), or a type of cut and thrust sword known as a tuck or estock (*estoc*). *Espée* is the old French word for sword (Hindley 2000:295). Old French was the spoken and written language of most of France between the late 5th and early 14th century, developing into Middle French spoken and written until the early 17th century.

A Dictionarie of the French and English Tongues, by Randle Cotgrave (1950:394) defines an *espée* as "a Sword; Rapier; Tucke; a Glaive, Cuttelasse, Faucheon, Hanger; or Blade…" and an *espée espagnole* specifically as a "rapier or tucke." Of note is the sword type *espée rabatuë*, defined by Cotgrave as "a foile." Of unknown origin, the term "foile" dates back to the middle of the 16th century, and was used both in reference to the act of dueling and various weapons employed for dueling. Cardinal Richelieu set up the Académie Française in 1634, the purpose of which was to produce a French language dictionary. In 1694 the first edition of the *Dictionnaire de l'Académie Française* was successfully published. The *Dictionnaire* defines an *Espée* as an *Arme offensive & defensive que les Gentilshommes, & ceux qui font profession des armes portent à leur costé.* The definition also includes a list of several sword types; *longue espée, courte espé, espée de longueu, espée de comba, espée à garde doré, and espée à garde d'argent.*

The continued practice of applying a number of widely used names to the same sword type makes the proper identification of specific sword types somewhat problematic. The simple, yet refined "small sword" was frequently referred to as a *court sword, presentation sword, town sword, walking sword,* or *pillow sword*. Another contemporary term used for lavishly decorated small swords was 'scarf sword,' because they were frequently worn on a waist or shoulder sash (Norman 1967:1).

Small swords recovered from the 18th-century French shipwreck *Machault*, were identified as French *à la mousquetaire* swords (Bryce 1984:31-33; Pétard 1987:8-12). In many cases, swords were identified not by specific type, but by the military rank and branch of service of the bearer, i.e., Infantry Sergeant's sword, Infantry Officer's sword, Cavalry sword (Chartrand 1984:22-23; Chartrand and Back 1988:18).

While terminologies and typologies are extremely useful for understanding sword history and development, these classifications are frequently modern constructs. Though our knowledge of the sword as a physical object increases, the nomenclature of this branch of weapons' study still remains incredibly fluid. Current scholars of edged weapon history remain remarkably inconsistent with their use of terms identifying the specific parts of a sword, preventing the development of an accurate and reliable terminology (Appendix B). The development of a systematic sword terminology is necessary for the proper documentation of existing weapons, and conducting additional edged weapons research in the future.

Sword Hilt Terminology

The hilt design of the small sword is unique. Intended as a light quick thrusting weapon it was designed for balance and speed. The small sword hilt is a simple structure, comprised of several components (Figure 3). Each component is constructed separately then assembled later to fit tightly around the tang of the blade. The small sword guard serves several functions. The most obvious purpose is to protect the hand of the sword wielder from the opponent's blade. The guard also prevents the hand of the wielder from sliding forward onto the blade, providing for a more secure grip. During a confrontation or combat, the guard can be used in unison with the blade, to “trap” or “turn” the opposing blade. The shape of the small sword guard can vary considerably. The classic form, as seen in the *La Belle* example, consists of two asymmetrical lobes coming together to form a flattened ‘figure eight’ or shell, and is slightly concave to the grip.

The quillon block or sleeve is a hollow piece of metal that extends outward away from the quillon toward the guard. The end of the quillon block is inserted into the guard, and is usually filed square, allowing for a much tighter fit. In most small swords, a small rectangular-shaped washer would be placed between the guard and the quillon block. The purpose of the washer is to firmly secure the guard and quillon block to the sword blade. This added precaution would ensure a firm grip and prevent the hilt from coming loose or rotating on the tang of the blade.

The quillon block could be cast as a single piece or two separate pieces, which would eventually be soldered together. Another important function of the quillon block is to support the remaining hilt components. The arms of the hilt, extending quillon, and knuckle bow are all soldered to the upper section of the quillon block just below the grip.

The arms of the hilt are two small semi-circular loops extending from each side of the quillon block, curving toward the guard. The arms of the small sword hilt are the vestigial remains of the much larger rings used on heavier military swords, which were used to protect the forefinger when it gripped the ricasso, the thick, unsharpened top portion of the blade where it meets the hilt for better blade control.

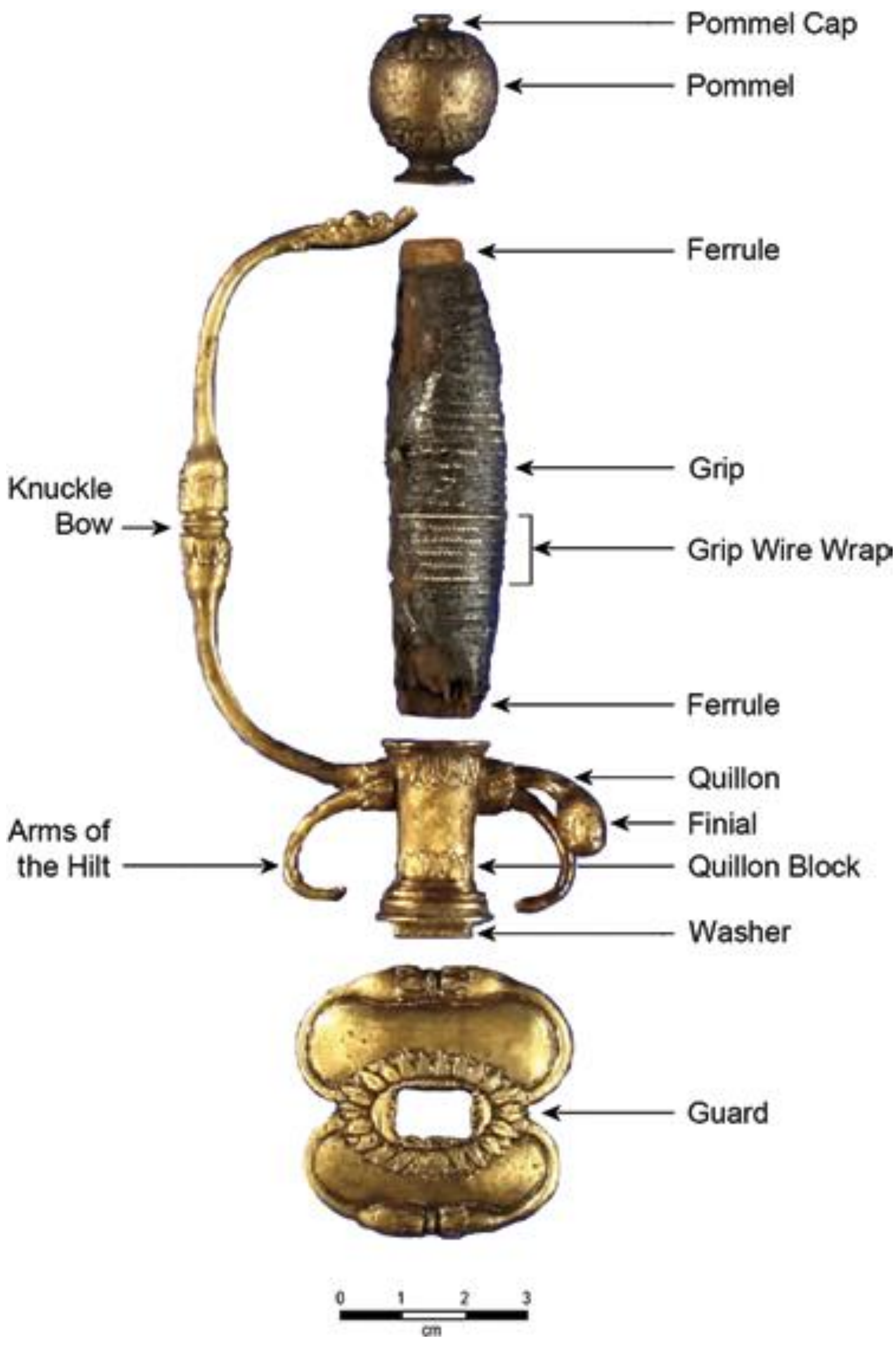

Figure 3. Exploded view of *La Belle* small sword hilt assembly (pommel, Artifact No. 2189; grip, 11500-37; quillon block, bow, etc., 11500-25; guard, 11500-36). *Photo by J. Kampfl*.

The size and style of the arms vary from sword to sword. The quillons of a small sword are invariably short, and, like the arms of the hilt, had ceased to serve any real function. Most small sword hilts have one quillon; however, it is not uncommon to find a hilt with two complete quillons. The finial, the knob at the end of the quillon, is often bent slightly toward the blade.

Quite unlike the complex hilt of a rapier with its bars and rings, the small sword has a single knuckle bow. Cast as a single piece, the lower end of the knuckle bow is soldered directly onto the quillon block, above the arms of the hilt. The opposite end, or stem, is often flattened and drawn to a small point. The stem is then inserted into a small hole located near the bottom of the pommel, and soldered in place. A thick leather glove, a shell guard, and the knuckle bow combine to protect the hand of the person wielding the small sword.

One of the more complex elements of the hilt is the grip. A small sword grip can be constructed out of almost any available material; wood, metal, bone, ivory, porcelain, or a combination of different materials have been used to construct small sword grips. They varied in section and shape from oval, nearly square, to circular with tapering ends, and were designed in such a manner as to prevent the sword from turning in the hand, providing for a much firmer grip. The need for a proper handhold was augmented by wrapping leather or cloth around the wooden grip, then arranging metal wire binding around the entire grip from top to bottom. The wire was frequently wound in a tight spiral or helix and often varied in degrees of thickness. On grips with wire binding, the wire would be wrapped many times around both ends of the grip forming a ferrule, which also served to reinforce the grip. The center of the wooden grip through which the tang passes, would be hollowed out, typically in the shape of a square, and secured into place by the pommel.

One of the functions of a small sword pommel is to secure the entire hilt assembly to the blade. An opening in the bottom of a hollow pommel is cut in the shape of a square, and positioned over the tang of the blade. The tip of the tang emerges from a small hole located at the top of the pommel, then is peened over the pommel cap until it is fixed firmly in place. Many pommels on later swords were fitted, threaded, and screwed into place. The pommel also serves as a counterweight or balance, allowing for greater blade control. Pommel designs are comparatively diverse and come in a wide range of sizes and shapes.

Sword Blade Terminology

An analysis of the manufacturing process and material makeup of a sword blade is essential to understanding the basic properties of any blade. Also essential is knowledge of the blade geometry, which refers to the dimensions and other diagnostic features of the blade: blade cross-section, width, thickness, length, and distal taper. The anatomy of a sword blade varies according to the sword type (Figure 4). The tang is the thin, reinforced section of the blade that runs through the grip, effectively attaching the grip and hilt components to the sword blade. As noted above, to achieve a secure grip, the tang, which is usually tapered toward the end, runs through the grip and pommel, and is then peened over onto the pommel. By the early part of the nineteenth century, the end of the tang was often threaded, and the pommel cap was screwed onto it. Ideally, the sword blade and tang were constructed as one solid piece, however; it was quite common to find blades with tangs that were welded on.

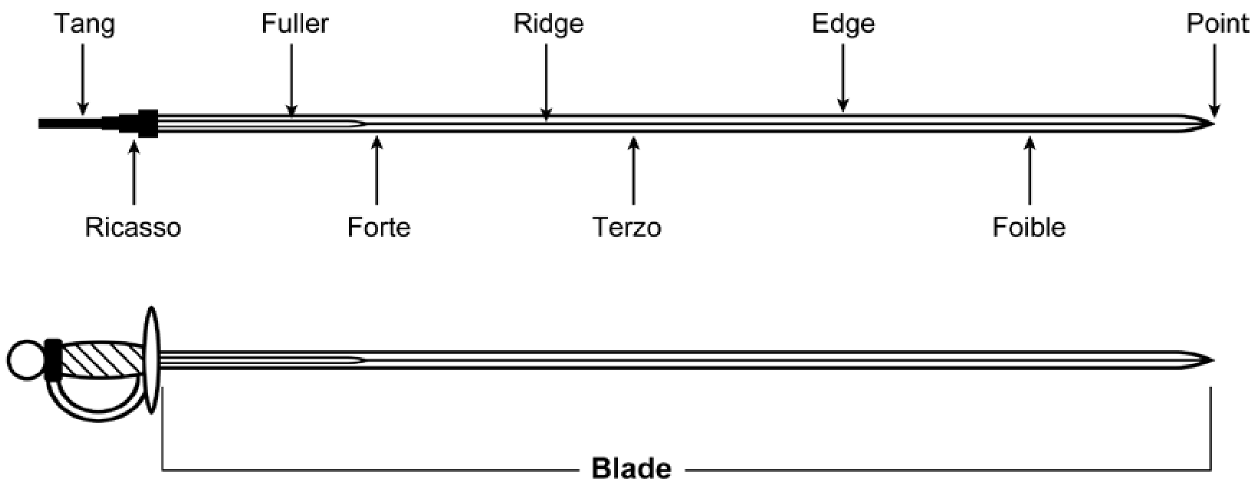

Figure 4. The anatomy of a small sword blade. *Illustration by J. Kampfl*.

The ricasso is the unsharpened section of the blade near the hilt and usually within the guards in front of the quillon. One function of the ricasso was to permit a combatant to bend a finger over a quillon, allowing for better blade and point control. The design of the small sword hilt and location off the lower guard meant that the use of the ricasso for this reason was no longer necessary. The fuller is a groove that runs the length of a sword blade. It is found on the blades of various sword types, including the rapier and small sword. The fuller is designed to lighten the blade without weakening it, while maintaining its flexibility. Variations include one or multiple parallel fullers worked into both sides of the sword blade. Several two-edged blades discovered on *La Belle* have a central ridge running the entire length of the blade (e.g., Artifact No. 7296-11.6). This ridge is a reinforced area designed to improve the rigidity of the blade.

The forte is that section of the blade closest to the hilt. It is the thickest section of the blade and most often used to parry. The terzo is the middle section of the blade located between the forte and the foible. The foible is the last section of the blade ending in the point. The blade is divided into these sections primarily as a tool to aid in the positioning of the blade during fencing bouts and training.

Small sword blades of the 17th-century typically had a flattened diamond or hexagonal cross-section with a central ridge (Figure 5). Two-edged blades with single or double fullers were common, as were blades with triangular cross-sections (Figure 6).

Blades with a hollow ground or triangular cross-section would narrow toward the point, turning the small sword into stabbing weapon. This type of blade was lighter in weight than the two-edged blades, making the small sword with this type of blade the preferred weapon of duelists, and eventually, those who would fence for sport.

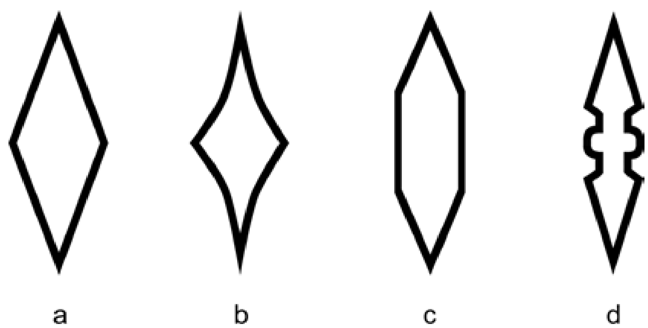

Figure 5. Examples of small sword blade cross-sections: *(a)*. diamond; *(b)*. hollow-ground; *(c)*. hexagonal; *(d)*. double-fuller. *Illustration by J. Kampfl*.

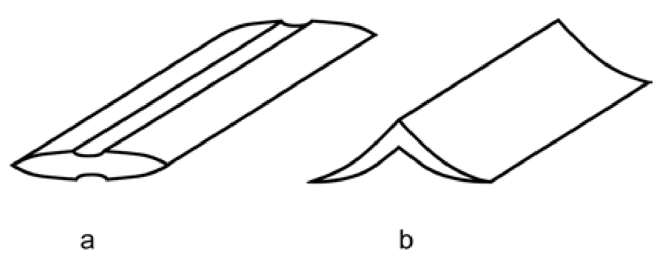

Figure 6. Two of the more common small sword blade cross-sections: *(a)*. two-edged single fuller; *(b)*. hollow triangular cross-section. *Illustration by J. Kampfl*.

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During the 17th century, sword blades were still being forged by individual blade smiths who retained the skills to continue their craft; however centers for the mass production of arms and armor were being established throughout Europe as early as the 14th century. During the 15th century, Toledo, Spain developed an exceptional blade making industry, which for nearly two centuries was regarded as the standard of excellence for European blade production (Calvert 1907:200-202). Only the German cities of Passau and Solingen could compete with Toledo in terms of production volume and blade quality.

Blade manufacturing centers such as Toledo, Passau, and Solingen exported their blades all over Europe and abroad (Gardner 1948:7-9). Throughout the 17th century, the French relied heavily on foreign-made blades, especially those imported from Solingen, both for military and civilian use. Not until the early part of the 18th century did King Louis XV establish a major weapons production facility within France. La Manufacture Royale d'Armes Blanches was established in 1730, in Klingenthal, Bas-Rhin, and continued to produce arms until 1962. Of note is the fact that manufacturing operations in Klingenthal began with the aid of blade smiths brought over from Solingen, Germany.

In 1665, the Royal Arms Depot was built in Paris to store weapons produced in Saint-Étienne (Lhost 1999). Blade smiths from Saint-Étienne had a reputation for crafting functional sword blades and assorted cutlery since the Middle-Ages. It was not until 1764 that the Manufacture d'armes de Saint-Étienne was established to mass-produce weapons of all types for the French military.

Signatures, initials, and other symbols often appeared on the blades of weapons crafted by individual smiths (Gardner 1963). As weapons production became more centralized, identifying marks representing weapons manufacturing facilities, such as the running wolf stamp of Passau, Germany, became more commonplace. Though the French made great strides in the quantity and quality of the blades produced in their manufacturing centers, sword blades from Germany remained the most sought after. Jacques-Raymond Lucotte, one of the many collaborators working with Diderot on the *Encyclopédie*, penned this article:

> The sword-cutlers of Paris never themselves forge the blades which they mount; they obtain them from the German provinces, from Franche-Comte, from St. Étienne-en-Forenz, and from other places. The first are, without contradiction, the best and the most esteemed; those from Franche-Comte are less valued; and those from St. Étienne, which they use in the army, are the least esteemed of all (Lucotte 1765:787).

Sword Scabbard Terminology

The remains of several sword scabbards were discovered on *La Belle*. A critical part of a soldier's equipment, a sword scabbard serves two essential purposes: it acts as a sheath for the sword, and it protects the metal blade from the elements. A well-made sword was a considerable investment, and protecting the blade from rust or other harmful agents was extremely important.

The scabbard can be as plain or elaborate in design as the sword; the hilt and metal scabbard fittings being decorated with engraving, punching, chasing, gilt, and other techniques.

Small sword scabbards can be constructed using a wide range of materials and combination of materials. The bodies of scabbards were frequently made of wood, metal, or boiled leather. According to Lucotte (1765:787), most French scabbards "are made of beechwood, which comes from the environs of Villers-Coterets." The scabbard body consists of two opposite pieces of wood cut to fit the sword blade and glued together. It is not uncommon to find scabbard bodies with a lining made of wool or some other naturally lubricating material. The finished scabbard body is wrapped with linen, followed by an outside covering of tanned leather. Shagreen, a type of untanned horse hide or the tanned skin of a shark or ray, was frequently used instead of cowhide.

The type of sword determines the size and shape of the scabbard. How the scabbard is to be worn and for what purpose, determines the type of fittings mounted on the scabbard (Figure 7). The scabbard fittings are often made of the same metal used to construct the sword hilt. The mouth of the scabbard is reinforced with a piece of metal, rounded over allowing the sword to be drawn and replaced smoothly. The throat is a flattened or ribbed section of metal that reinforces the upper part of the scabbard. The middle band reinforces the middle or upper middle section of the scabbard body, and, along with the throat, serves as an anchor for suspension devices. The chape reinforces the bottom section of the scabbard. Along with the finial or drag, the chape also serves to protect the scabbard from damage, especially if worn on a belt or hanger, an elaborate type of sword belt.

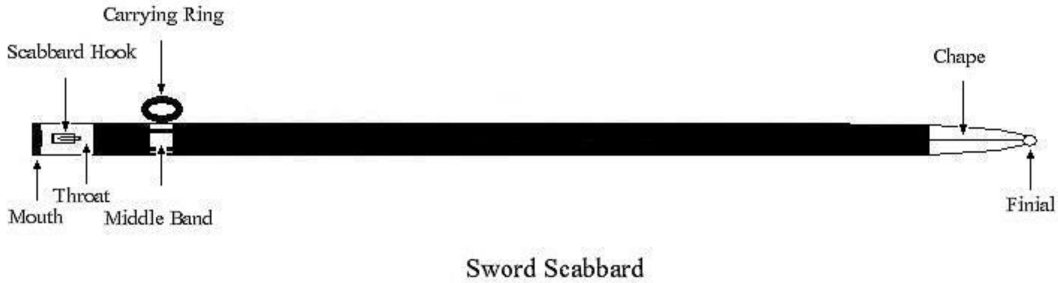

Figure 7. Diagram of a small sword scabbard. *Illustration by J. Kampfl.*

The scabbard is worn using one of three suspension apparatus. Leather straps or a length of chain would run from a sword belt to one or two metal carrying rings located on the upper half of the scabbard. A baldric is a shoulder belt or sash worn over the left or right shoulder. A scabbard button or hook attaches the baldric to the scabbard. A scabbard hanger consists of a sword belt from which hangs several leather or cloth straps and a series of buckles. Buckles and hooks are used to attach the straps near the front of the belt and to the side. The ends of the straps are simply folded over or under, and run through the buckles, forming a series of loops. These loops serve as a sort of pouch from which the scabbard hangs.

Small Sword Fencing and Instruction

When dealing with the subject of small sword scholarship, two problems immediately come to the fore: primary sources describing the early development of the small sword are almost non-existent, and most sources dealing with the use of the weapon post-date the cache of weapons discovered on *Belle* (Mondschein 2006:25-34. Though the small sword developed early in the first half of the 17th century, the first treatise written on the use of this weapon did not appear until the latter half of the century. An increasing corpus of small sword literature published from the early 18th century on, serves as an indication of the growing popularity of the small sword throughout Europe during this period. The small sword would become particularly popular in France, and as the Italians and Spanish perfected the art of rapier fencing, the French would establish themselves as the preeminent masters of *l'épée de cour*.

The light weight, hilt design, and shorter blade of the small sword made a more intricate and defensive style feasible. The French school of small sword emphasized finesse, subtle wrist action, and multi-faceted attacks and defense techniques, accentuating the thrust over the cut. This type of fencing appealed more to the refined, gentlemanly classes of high French society. The newly developing sport of fencing was "maintained by the gentry, and the schools were frequented only by noblemen and aristocrats" (Palffy-Alpar 1967:14-17; Mondschein 2006:25-34).

The French fencing master Philibert de La Touche (1670) published *Lesvrays principes de l'espée seule*, a limited treatise and early predecessor to the developing French school of small sword use. Philibert was perhaps the first to illustrate the small sword as a new type of weapon; its application restricted to the increasingly popular sport of fencing rather than the battlefield. The addition of a small protective knob, or *le fleuret*, attached to the point of the blade allowed for training matches to take place, minimizing the risk of serious injury to the fencers.

Offering a critique on the French school of small sword, Sir William Hope published no fewer than seven fencing treatises between 1687 and 1724 (Rector 2001:87). The Scotsman's first treatise, *The Scots Fencing Master*, was a short work expanding on the established French system of small sword (Hope 1687:158-59). Hope focused on proper self-defense techniques, his ‘common method’ centering on the fundamental techniques and tactics of small sword fencing. Hope argued that a small sword in the hands of a well-trained and competent swordsman could be used to defend against heavier blades, and much like his predecessor George Silver, advocated a more militant approach to weapons training (Hope 1707).

Summation

The historiography of edged weaponry has by and large focused on the description of armory collections, recent museum acquisitions, and antiquarian and collectors’ guides, and discussions of broad developmental or artistic trends (Schöbel 1975; Held 1979; Nickel 1982; Norman 1982; Weland 1991; Krenn and Karcheski 1992; Fliegel 1998). There is a considerable amount of literature devoted to sword research and the general study of arms and armor (Stone 1961; Reid 1976; Miller 1982; Bull 1991; Hogg 1992; Dolinek et al. 1993; Robinson 1995). A serious deficiency shared by all arms and armor research is the complete lack of a standardized sword and sword component terminology that is both coherent and comprehensive.

Most literature pertaining to the type of 17th-century edged weaponry discovered on *La Belle* is descriptive in nature, and focuses on the already well documented collections of national armories and museums (Aylward 1960; Blair 1992; Norman 1992; Bull 1999; Kampfl 2017:480-498).

Warfare in the 17th-century has been the ongoing subject of many scholarly debates (cf. Childs 1982; Black 1991, 1996; Rogers 1995). It is in this wider historical context that the weapons of *La Belle* must be placed. Military historians of 17th- and 18th-century Europe have devoted most of their energies attempting to define the “nature and chronological location of a

Military Revolution" (Childs 2003:22). Many historians argue that the revolution centers on the symbiotic relationship between state formation and the newly developing military organizations of 17th-century Europe (Parker 1988; Barker 1982; Parrott 2001).

Others maintain that the adoption of more reliable weapons, the flintlock, and socket bayonet, by standing armies was the crucial, 'revolutionary' development (Black 1994; Hall 1997). The adoption of new military technology and tactics in the 17th century, had for many historians, relegated the sword to the backwaters of military history (Hughes 1997; Brown 1981). In truth, the sword had remained an essential implement of war well into the 19th century (Peterson 1947:197-208).

The quality and quantity of weapons located on the *La Belle* site are in-part, an indication of the resources available to La Salle, and reflect to what extent and by whom the weapons were to be used. Research addressing the standardization of arms and armor, especially in the French military, may offer an explanation as to the number and more importantly, the types of weapons discovered onboard *La Belle* (Hicks 1964; Martin 1967; Gaier 1979; Reverseau 1990; Lynn 1997; Brasseaux 2000). The following chapter on the analysis of the swords from *La Belle*, will shed important new data on the study of 17th-century swords; their manufacture, material makeup, and how these weapons reflect cultural trends in terms of sword decoration.

CHAPTER IV

ARTIFACT ANALYSIS

Among *La Belle's* stores and equipment were a large number of swords and sword-related artifacts. Of the "150 swords and the same number of sabers" requested by La Salle for his expedition to the New World (Louis XIV 1877:378-380), most were probably loaded on *L'Aimable*, the supply ship of the colonization effort, which sank as she tried to enter Matagorda Bay. Only a small fraction of these swords were discovered among the wreckage of *La Belle*. Seventy-one sword artifact lots were recorded and most were of the type known as "small sword." A number of hilt components, blade segments, and scabbard attachments possibly belong to other sword types. A unique sword hilt in the collection, Artifact No. 12930, likely represents one of the only examples of the sabers requested by La Salle for his expedition.

The purpose of this chapter is to identify, describe, and interpret the swords and sword-related artifacts recovered from *La Belle*. The classification system used here follows the small sword typology developed by A.V.B. Norman in his definitive book on the subject, *The Rapier and Small-Sword 1460-1820* (Norman 1980). Considering the quantity of sword-related artifacts recovered from *La Belle* (Table 1), only a representative sample will be discussed here of each artifact type, focusing on those that retain most of their diagnostic features. Unfortunately, determining the origin or place of manufacture of these weapons is nearly impossible because none of the hilt components or blades bear any kind of maker's mark or stamp.

Artifact Identification and Analysis

The sword artifact assemblage is a mixture of isolated component parts and complete and partial hilts. Fifty-one of the artifact lots, 72 percent, were recovered from Box 3 (Artifact No.7296; Figure 8). Based on the quantity of complete or mostly complete grips, with and without their associated hilt components, the total number of swords contained in Box 3 is approximately 28 (Table 1). Of the sword artifacts from outside of Box 3, based on grips and partial sword hilts, there were at least eight additional swords. A majority of the hilt assemblies were manufactured of iron, perhaps as much as 83 percent, including all but one contained in Box 3. Three of the eight "swords" outside of Box 3 were solely grips (Artifact Nos. 5513, 7610, 10098), though a number of detached knuckle bows, guards, and pommels (largely of brass) may be associated with these artifacts. Three of the remaining five hilts were made of brass (Artifact Nos. 1102, 11500-25, 13282) and two were of iron; (Artifact Nos. 7707, 12930).

Artifact No.	Main Attributes	Original Material	Total Swords
736	Knuckle bow, quillon	Brass	1
1102	Knuckle bow, quillon, grip, pommel	Brass, wood	
2189	Pommel	Brass	
2371	Chape	Brass	
3062	Pommel	Brass	
3493	Knuckle bow	Brass	
4067	Scabbard Hook	Brass	
4769	Pommel	Brass	
4992	Pommel	Brass	
5203	Knuckle bow tip	Brass	
5513	Grip	Brass	1
7707	Grip, pommel	Iron	1

Table 1. Swords and related artifacts from Box 3. The total number of swords in Box 3 was 28.

Artifact No.	Main Attributes	Original Material	Total Swords
7142	Scabbard Hook	Brass	
7296-2	Grip fragment, scabbard, blades	Wood, iron	
7296-3	Blade and Scabbard	Wood, iron	
7296-4	Guard fragment, grip, blade	Wood, iron	1
7296-5	Guard, pommel, grip, scabbard, blade	Wood, iron	1
7296-6	Guard fragment, blades	Iron	
7296-7	Knuckle bow	Iron	
7296-8	Quillon, guard, grip, pommel, blade	Wood, iron	1
7296-9	Quillon, guard, grip, pommel, blade	Wood, iron	1
7296-10	Blades	Iron	
7296-11	Guard, pommel, grip, blade, scabbard, chape	Wood, iron	1
7296-12	Pommel, grip	Wood, iron	1
7296-13	Quillon, guard, grip, pommel, blade	Wood, iron	1
7296-21	Pommel, grip	Wood, iron	1
7296-24	Scabbard, blade	Wood, iron	
7296-28	Blade	Iron	
7296-29	Quillon, guard, pommel, grip, scabbard, blade	Iron, wood	1
7296-30	Quillon, pommel, grip	Iron, wood	1
7296-33	Guard, pommel, grip, scabbard, blade, chape	Iron, wood	1
7296-39	Undetermined mold, unknown sword fragments. Blades	Iron (?)	
7296-40	Quillon, guard, pommel, grip, blade	Iron, wood	1
7296-41	Guard, scabbard, blade	Iron, wood	
7296-45	Guard, pommel, blade	Iron, wood	
7296-46	Blade, scabbard	Iron, wood	
7296-50	Pommel, grip	Iron, wood, silver	1
7296-51	Pommel, grip	Iron, wood	1
7296-54	Blade, scabbard	Iron, wood	
7296-55	Blade, scabbard, chape	Iron, wood	
7296-60	Guard, pommel, grip, guard, scabbard, blade	Iron, wood	1
7296-61	Quillon (3), guard (3), pommel (3), grip (3), blade (2)	Iron, wood	3
7296-62	Blade	Iron	
7296-63	Scabbard, blade	Iron, wood	
7296-64	Pommel, grip fragment	Iron, wood	
7296-65	Quillon, guard, pommel, grip fragment, blade	Iron, wood	
7296-66	Scabbard	Iron	
7296-67	Guard fragment	Iron	
7296-68	Guard fragment	Iron	
7296-69	Scabbard, blades	Iron, wood	

Table 1 Continued. Swords and related artifacts from Box 3. The total number of swords in Box 3 was 28.

Artifact No.	Main Attributes	Original Material	Total Swords
7296-70	Scabbard	Wood	
7296-75	Blade	Iron	
7296-76	Grip impression	Wood	
7296-77	Blade, scabbard	Wood	
7296-81	Pommel, grip	Iron, wood	1
7296-82	Guard fragment	Iron	
7296-83	Blade	Iron	
7296-84	Guard fragment	Iron	
7296-92	Blade, scabbard	Wood, iron	
7296-93	Grip	Wood	
7296-94	Pommel, hilt fragments	Iron	
7296-95	Blade	Iron	
7296-96	Grip	Wood	1
7296-97	Guard fragment	Iron	
7610-1	Grip	Wood	1
7955	Scabbard Hook	Brass	
10098	Grip	Wood	1
10820	Guard	Brass	
11500	Knuckle bow, quillon, guard, grip	Brass, wood, silver	1
12930	Knuckle bow, guard, grip, pommel, blade	Iron, wood, silver	1
13282	Knuckle bow, quillon, guard, grip, pommel, blade, scabbard	Brass, iron	1

Table 1 Continued. Swords and related artifacts from Box 3. The total number of swords in Box 3 was 28.

Almost all of the hilts recovered from *La Belle* are believed to be representative of the "true" small sword, an edged weapon that had widespread civilian and military use at the time. Saint-Remy (1939:292) illustrates this hilt type on basic military swords and those used by the Corps de la gardes, the latter being the king's personal body guards. In the French military, every infantryman was equipped with a sword. Gilded or silver-plated swords were for officers and often sergeants; troops were equipped with those of brass or "indifferent" quality (Chartrand 2005a:20).

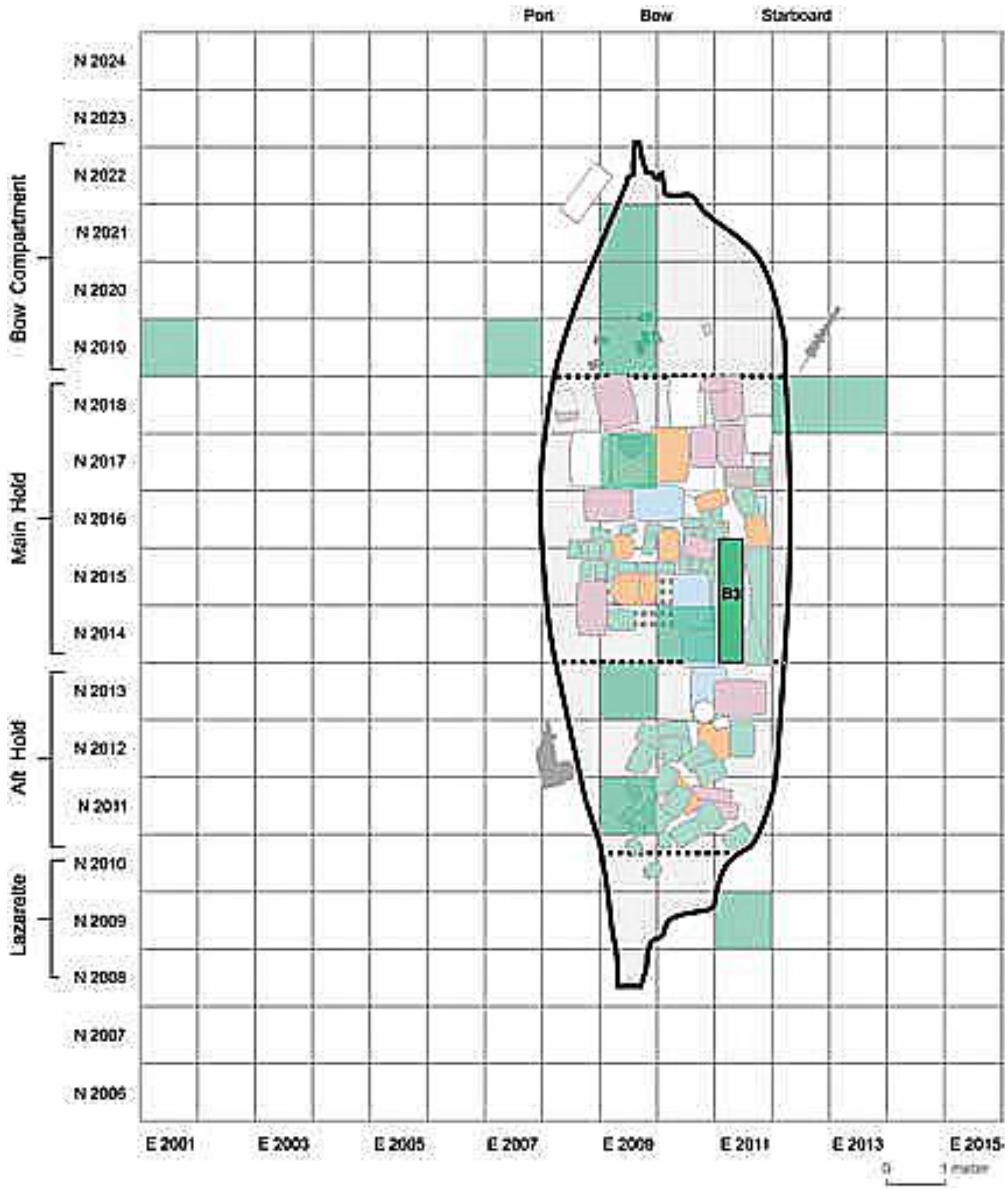

Figure 8. Location of the sword artifacts. *Illustration by the Texas Historical Commission.*

The majority of the swords from *La Belle* were grouped together within Box 3, along with 32 flintlocks, and included a mixture of hilt assemblies, blade fragments, and scabbard components, all of which comprised badly deteriorated complete swords prior to their removal from the box. Of the sword artifacts recovered outside of Box 3, several may have been associated with the weapons boxes based on their provenience within the hull. These include Artifact Nos. 5203, 7610-1, 7707, and 10098. Artifact No. 5203 is a brass knuckle bow; 7610-1 is a wood grip; 7707 is an iron pommel and wood grip; and 10098 is a wood grip. Both 7610-1 and 10098 were recovered from Box 5, one of the weapons boxes. Artifact Nos. 5203 and 7610-1 were both from the same unit, 2014N/2011E, so they may have comprised the same hilt which would have then included a wood grip and brass knuckle bow.

Sword Hilt Assemblies

Only three complete and intact brass sword hilts were identified (Artifact Nos. 1102, 11500-3, -25, -36, -37, 13282-1, 13282-2), and a forth partial hilt may suggest a unique type not encountered elsewhere on the site (Artifact No. 3493). In addition, an artifact with an iron hilt (Artifact No. 12930) is the only saber encountered in the collection. Because a majority of the sword hilts were of iron, the poor preservation of these artifacts precluded conservation of many of the components, though epoxy casts were created when possible.

One of the most complete hilt assemblies excavated from *La Belle* is a small sword hilt (Artifact Nos. 1102-1, -2, -3) that was discovered at the top southeast corner of the heavily concreted weapons crate, Box 3 (Franklin 1996) (Figure 9). This is the only example of a brass hilt recovered from Box 3. This hilt assembly was discovered completely intact, with a Norman type 112 hilt and a type 86 pommel (Norman 1980:199-212, 278). The type 112 hilt design dates from the 1640s, possibly earlier. The overall length of the hilt, from the pommel cap to the

Figure 9. Complete small sword hilt from Box 3, Artifact No. 1102-1. *Photo by J. Kampfl*

end of the quillon block, is 138mm. The knuckle bow measures 103mm from the tip of the top finial connected to the pommel to the bottom finial attached to the quillon block. The approximate length of the pommel is 30.31mm, and the diameter is 25.50mm. The wooden grip measures 83.10mm in length. The diameter of the grip at its widest point in the center is 34.00mm, tapering off toward both ends. The guard measures 67.00mm in length by 65.60mm wide.

The metal components were manufactured individually of cast brass. These would have been assembled and decorated at a later date by a skilled swordsmith or metalsmith (Diderot and d'Alembert 1751-1772: *Fourbisseur,* Plate IV, Figures 44, 47, 50-51, 56). The entire brass hilt was incised and chased on top and bottom with both religious and military motifs, ribbons, and accentuated foliage patterns (Figure 10.a-d). The bottom of the guard, both sides of the quillon block, the knuckle bow, and the pommel are decorated with classical nude male and female figures. These are among the most common types of decoration found on 17th-century European small swords (Norman 1980:383-395). The aperture of the guard, through which the blade passes, is outlined with acanthus leaves rendered in low relief. The knuckle bow on this particular hilt is flat, with a large single quillon bent toward the blade.

Figure 10. Detail of ornamentation on Artifact No. 1102-1: (*a*) knuckle bow; (*b*) top of guard; (*c)* obverse of guard; (*d*) quillon block. *Photo by J. Kampfl*.

The grip of the hilt survived fairly well, though exposure to the elements caused it to split longitudinally in several places. Remains of the tang were still in the grip and had to be extracted prior to conservation. Traces of a leather grip cover remained and impressions left in the wood indicate that the entire grip was at one time wrapped with twisted iron or possibly wire braiding. The leather wrapping and wire binding would make for a much firmer grip when wielding the weapon.

An assortment of small sword hilt components (Artifact Nos. 11500-25, -36, -37) was among the contents of a wooden chest (Box 10, Artifact No. 11500) discovered aboard *La Belle* (West 2005:55-59; Chapter 30) (Figure 3). Along with a detached small sword guard (Artifact No. 11500-36), the chest had an assembled knuckle bow complete with side rings, a quillon block, and a single extending quillon (Artifact No. 11500-25). All of the hilt components are of cast brass. A wooden grip with a leather covering bound with silver wire braiding (Artifact No. 11500-37) was also discovered. The chest did not contain a pommel, although a Norman type 86 pommel (Artifact No. 2189) bearing the same style of decoration as the hilt was discovered among the wreckage earlier and used as a replacement by the author for analysis of the hilt assembly.

One of the aspects of this Norman type 112 hilt assembly is its comparatively small size. The total length of the hilt without the pommel is 113mm. The knuckle bow is only 80.07mm in length. The wooden grip measures 75mm in length and 20mm at its widest point in the middle. The length of the guard is a mere 44mm, its width measuring from center only 41.03mm. A sword of this size would hardly have been suitable for combat, and may have been fashioned originally for a child. Such swords were made for children of the nobles and wealthy, because these families could afford training in fencing for their youth (Evangelista 1995:106). The fact that the hilt was found disassembled is an indication that hilt components could be and often were reused, or it is entirely possible that the owner of the chest simply meant to recycle the metal for some other purpose.

The quillon block and central lobes of the knuckle bow are decorated with acanthus leaves cast in relief. The guard was also cast with acanthus foliage, radiating outward from the blade aperture. This classical type of floral decoration, popular throughout Europe from the mid-17th century on, was based on the scalloped shaped leaves of the acanthus plant (Norman 1967:11). A post-cast finishing technique known as punching was used to decorate around the acanthus design and along the entire edge between the flat part of the guard and the rising outer edge.

As the sword hilts from *La Belle* indicate, the styles and types of decoration varied considerably and many of the surviving hilts, whether of iron or brass, bore decorative markings. Techniques such as punching, chiseling, incising, chasing, and piercing, and the tools used to decorate sword hilts were the same regardless of the type of metal used. Deep chiseling or engraving, frequently offset by patterns created with circular punches, was an extremely popular form of sword decoration throughout the 16th century. Brass sword hilt components could be decorated by hand; however the casting process, which produced brass sword hilts in large numbers cheaply, could also be used to replicate decorative techniques such as chiseling (Norman 1980:368).

The waterlogged wooden grip survived intact. Remnants of the leather grip covering were also discovered, along with a very fine silver wire braiding wrapped around the entire length of the grip. The grip was devoid of any tang remains and there was no evidence of a sword blade discovered in Box 10.

Two cast brass hilts, Artifact Nos. 13282-1 and 736 (Figure 11), are nearly identical in form and type to the hilt from Box 10, Artifact No. 11500-25. Artifact No. 13282-1 is nearly complete and bears the same style of acanthus leaf decoration, with small punched indentations lining the inner edge of the guard. There is only a slight variation in dimension: the length of the hilt from the top of the pommel to the bottom of the quillon block is 140 mm. The knuckle bow measures 95 mm in length from finial to finial.   With the pommel cap in place, the entire pommel measured 30 mm in length, with a diameter of 21 mm. The somewhat asymmetrical guard is of a bilobate design, with the longest plate measuring 49.3 mm in length and the slightly shorter plate measuring 47.4 mm. The overall width of the guard measures 51.1 mm. The aperture measures 15.1 mm in length and 6.5 mm wide.

Figure 11. Brass small sword hilts, Artifact Nos.: (*a*) 13282-1; (*b*) 736. *Photo (a) by J. Kampfl; photo (b) by the Texas Historical Commission.*

What little of the wooden grip that remained from the hilt assembly (Artifact No. 13282-2) measures 62 mm long, with a diameter of 18 mm at its widest point. A bit of leather wrapping remained around the grip, and deep impressions in the wood indicate that it was at one time wrapped with twisted wire braiding. X-rays revealed that the grip contained remains of the tang, and a small section of the blade below the guard was still encased in concretion (Artifact No. 13282-6). Though the tang and blade section were both completely corroded and had to be removed prior to conservation, the x-ray provided a clear image of a double-edged, diamond-shaped sword blade.

The diminutive size and relatively poor quality of these particular small sword hilts indicate they may have served a more ceremonial function, rather than a military one. Small swords such as these were often worn with civilian attire or military dress uniforms. Made of cast brass and somewhat crudely decorated, these small swords were still functional weapons and deadly in the hands of a trained swordsman.

Artifact No. 736, though more poorly preserved, only consists of the brass knuckle bow, quillon block, and the arms of the hilt. It is slightly less decorative than Artifact Nos. 1102-1, 11500-25, and 13282-1 though it resembles these hilts in design; the original surface preservation is poor and this may make decorative inlays less discernable. The hilt is incomplete and is missing a small portion of the lower edge or the quillon block. The complete length of the artifact is 130 mm and the length of the knuckle bow itself is 103 mm. The quillon block is 34 mm and 17 mm wide.

In addition to the brass hilt assemblies, the assemblage contained approximately 19 iron-hilted swords in Box 3, packed together atop the firearms (Helen Dewolf, personal communication 2014), and portions of two iron hilts were excavated from elsewhere on the wreck site (Artifact Nos. 7707, 12930). The preservation of the iron from the swords in Box 3 was poor and conservation of these artifacts largely encompassed molding and casting surviving portions of the hilt; measurements of an intact original attribute could not be recorded for most of the iron hilt components. The iron hilts were most likely made of wrought iron. Wrought iron is produced when iron ore is heated to temperatures high enough to separate the ore from its surrounding impurities, but not reduce it to a liquid state. Repeated hammering facilitates the removal of any impurities, but also lowers the carbon content of the iron, resulting in a softer, more malleable metal. For this reason, using refined and precision techniques such as incising and chiseling to decorate iron hilts is very difficult. Much harder steel hilts had to be individually forged and decorated by hand, making this a more costly and time-consuming endeavor (Dean 1916:42-43; Williams 1999:101-124).

Reconstructing these assemblies from the radiographic images (Figure 12) and preserved remains easily demonstrates the diversity of arms contained in Box 3. Though these were all small swords, there was much variability in overall size, pommel dimensions, quillon finials, and grip shape. Knuckle bows were often not visible in the x-rays, except in a couple of examples (wherein they belonged to an altogether different hilt), and only one was cast (Artifact No. 7296-7). The most complete preserved guards were unadorned (Artifact Nos. 7296-8 and 7296-9). This was not always the case, as impressions of some of the guards demonstrated some were decorated (Figure 13). The partial remains of three small sword guards (Artifact Nos. 7296-11.3, -67.1, -82) had complex foliage patterns, accented with strapwork, all outlined with a series of punched depressions. The careful conservation of the surviving remnants of a small sword guard (Artifact No. 7296-11.3) revealed the remarkable image of a fleur-de-lis, surrounded by geometric patterns, all rendered in low relief. On two guards a small segment of copper or brass bounded a guard panel (Artifact Nos. 7296-5.3, 7296-11.3) and this may have been a decorative element sometimes observed on iron swords.

An iron sword hilt (Artifact No. 12930), discovered lying outside the hull, was completely encased in concretion (Figure 12k). The concretion consisted of a light-brown sandy loam matrix. Preliminary x-rays revealed an impressive saber hilt assembly, complete with blade remains. The iron had degraded and the natural mold in the concretion was used to create a cast

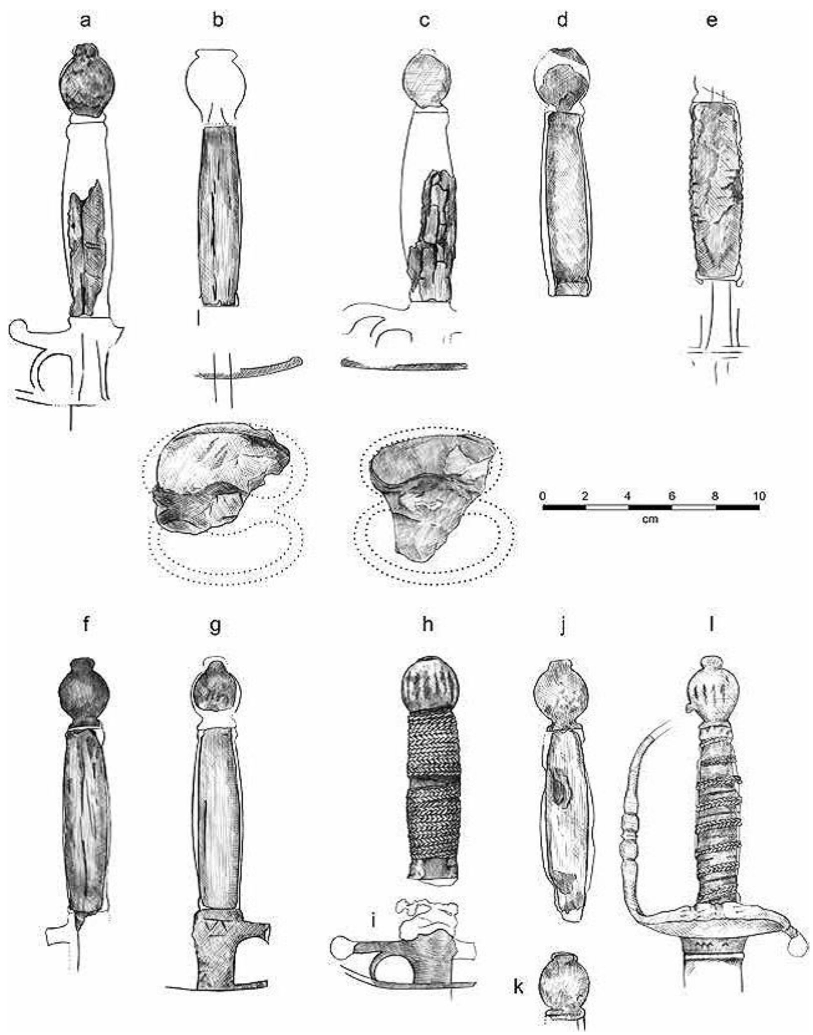

Figure 12. Iron sword hilts combining artifacts (shaded) and x-ray data. Artifact Nos.: *(a)* 7296-5.1, -5.2; *(b)* -8.2, -8.3; *(c)* -9.1, -9.2, -9.3; *(d)* -12.1, -12.2; © -13.2; *(f)* -30.1, -30.2; *(g)* -40.1, -40.2, -40.3; *(h)* -50.1, -50.2; *(i)* -65; *(j)* -51.1, -51.2; *(k)* -45.1; *(l)* 12930. *Illustrations by A. Borgens, Texas Historical Commission.*

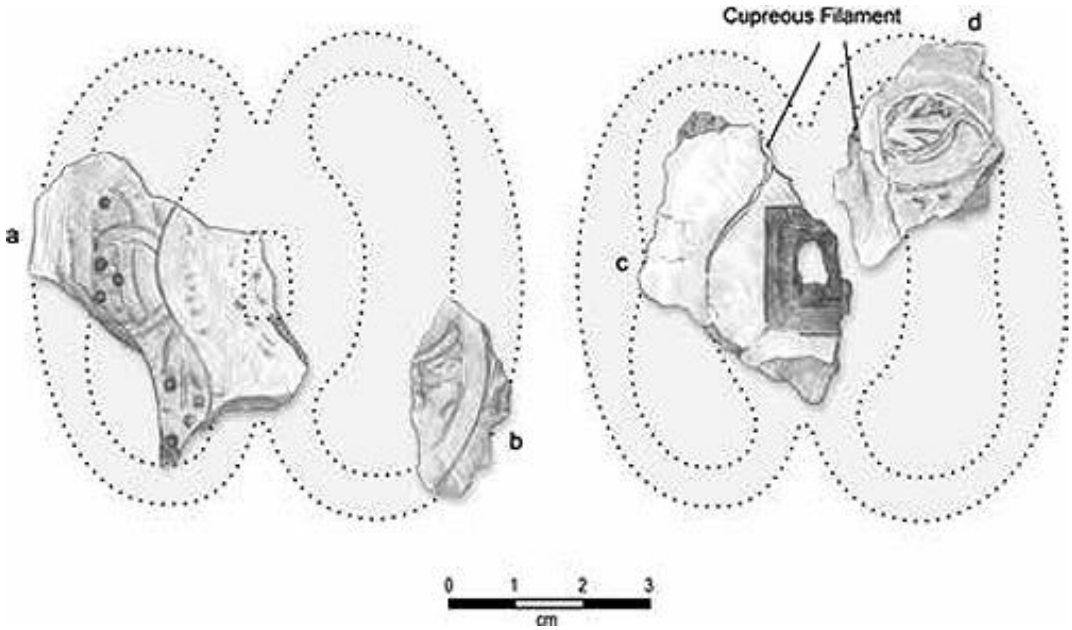

Figure 13. Decorative ornamentation on iron hilts from Artifact Nos.: *(a)* 7296-67.1; *(b)* -82; *(c)* -5; *(d)* -11. Artifacts superimposed on an outline of Artifact No. 1102-1. *Illustration by A. Borgens, Texas Historical Commission.*

of the artifact. The hilt is unique among the small swords discovered on *La Belle*, and is the only example of the type of hilt equipped on sabers. This hilt style is depicted on sabers used by French cavalry (Saint-Remy 1697:292) and a similar version is shown on a mid-18th century grenadier's saber (Chartrand 2005b:23). Like the infantry, all grenadiers were outfitted with edged weapons. Instead of the infantry-issued small sword, the grenadiers were provided with sabers (Chartrand 2005a:21; Pétard 2006).

The wooden grip is wrapped with brass wire braiding. The grip is approximately 84 mm long. The width at the center of the grip is 18 mm, measured from the outside edge of the braiding. The conserved wood grip itself measures 15 mm x 14 mm at its widest point at the middle of the grip. The pommel measured 34 mm in length with the diameter at its widest measuring 24.5 mm. The single plate of the guard measured 67 mm long, 30.3 mm wide, and

15.5 mm deep. The overall length of the hilt was 123 mm. Approximately 125 mm of sword blade survived bringing the total length of hilt and blade to 240 mm.

An isolated partial hilt, consisting of only a quillon, a partial quillon block, and a partial knuckle bow, was excavated from the aft hold that may represent an altogether different type of edged weapon. Former La Salle crewman Jean L'Archevêque and Jacques Grollet revealed to their Spanish captors that the men were often armed with cutlasses (O'Donnell 1936:17, 19). The only possible evidence of this sword type excavated from *La Belle* was the remains of a crudely fashioned brass sword hilt (Artifact No. 3493), which bears no discernible markings or decoration (Figure 14a). No other sword-related artifacts were discovered in association with

Figure 14. Large brass sword hilt, Artifact No. 3493: *(a)* obverse view; *(b)* reverse view. *Photo by the Conservation Research Laboratory, Texas A&M University*.

this hilt, making a positive identification difficult. A metal burr that extends outward from the quillon block could be the vestigial remains of a lower circular guard found on a typical loop-guard hilt. A better explanation may be indicated by the connection of this burr to an irregular lip or ridge (Figure 14b) that collectively extends 87 mm along the quillon towards the knuckle bow. This appears to be a break rather than a design element, and is suggestive of the simple asymmetrical sword guards recovered from the wreck of the French vessel *Alcide* lost in 1747 off the French coast (Dagneau 2008:117, 483). This hilt, which was considerably larger than any of the other sword hilts recovered from *La Belle*, measures approximately 122 mm from the end of the finial to the knuckle bow just above the lower bend, with the finial extending 4.5 mm beyond the quillon block. The quillon block measures 18.02 mm in length and 11 mm in width. The size and shape of this hilt indicate that it does not belong to a small sword.

Sword Guards

A single detached cast brass small sword guard was recovered during the excavation. Artifact No. 10820 is an asymmetrical, bilobate design, with the longest plate measuring 66.5 mm in length and the shortest plate 60.02 mm long (Figure 15). The overall width from the outer edges of the plates is approximately 63 mm. The blade aperture is 15.55 mm in length and 11 mm wide. One of the most common forms of hilt decoration, a stylized acanthus leaf pattern, surrounds the blade aperture. The plates on both sides of the guard are decorated in similar fashion, with busts dressed in classical and contemporary garb, flanked by winged angelic forms, detailed scroll work, and panels.

Figure 15. Cast brass small sword guard, Artifact No.10820: front *(top)* and back views. *Photo by J. Kampfl*.

Sword Pommels

A total of 28 pommels were recorded (Table 1), most as part of a partial hilt assembly and four detached brass pommels were discovered unassociated with other sword components throughout the wreck site (Artifact Nos. 2189, 3062, 4769, 4992). The first is a Norman type 86 brass small sword pommel (Artifact No. 2189), which bears a striking resemblance to the pommel of a complete hilt assembly discussed earlier (Artifact No. 13282-1; Figure 16a). This type of pommel dates from about 1650 to the early-18th century, is usually globular in shape, and is almost always decorated with acanthus leaves on the top and bottom. This style of pommel is one of the most common types found on both civilian and military swords of the period, and the most numerous type of pommel found on *La Belle* (Norman 1980:278-280). The pommel possesses two small holes: one near the bottom where the top finial of the knuckle bow

Figure 16. Small sword pommels: *(a)* globular, Artifact No. 2189; *(b)* Norman type 86, Artifact No. 4992; *(c)* Norman type 88, Artifact No. 3062; *(d)* Norman type 88, Artifact No. 4769. *Photo by J. Kampfl*.

would have connected to the pommel, and one on the top of the pommel cap where the tip of the tang would have passed through and then been peened over to hold the hilt assembly together. The pommel measures 25 mm from top to bottom. From its widest point at center, the diameter measures approximately 20 mm.

A variant of the type 86, a second isolated brass pommel (Artifact No. 4992), measures 32 mm from pommel cap to lower rim, with a diameter of 24.5 mm at its widest point in the center, being somewhat larger than the previously discussed type 86 pommel (Figure 16b). This example has a slightly elongated acorn shape, and is decorated with simple vertical fluting all around. The pommel undoubtedly suffered some damage since the lower rim is bent, with a small piece of metal missing.

The other detached pommels (Artifact Nos. 3062, 4769) are larger. Both larger brass pommels are nearly identical in size and shape, and are excellent representations of the Norman type 88 pommel (Figure 16c, d). First seen on sword hilts dating back to 1670, these egg-shaped pommels became extremely popular between 1710 and 1780 (Norman 1980:280). By the early 18th century, this style of pommel would become one of the most common types found on small swords and loop guard hilts. Neither of *La Belles* examples bore any type of decoration or metalwork.

The larger of the two (Artifact No. 3062) measured 39.7 mm from pommel cap to lower rim, having a diameter of 31.5 mm. The second pommel (Artifact No. 4769) was only slightly smaller measuring 37 mm from pommel cap to lower rim, with a diameter of 30 mm. The large side holes indicate that both pommels were made for fair-sized knuckle bows. The bottom openings, through which the tang passes, are quite large, though this does not necessarily mean they were fitted with larger blades. The tang of most blades was often tapered to fit any given pommel or grip assembly.

None of the iron pommels survived; however, casts made from the concretions will provide important diagnostic information. The pommel "type" is not determined by the kind metal it is made of, but rather its size, shape, and decoration. Pommel casts were made from Artifact Nos.

7296-5, -8, -33, -45, -51, -71, and -81. The size and shape of the casts are similar to those of the Norman type 86 brass pommels; unfortunately none of the iron pommel casts bore any discernible decorative markings.

Sword Grips

The assemblage was comprised of at least 33 grips, deduced from complete artifact examples, artifact fragments, and radiographic analysis. Three examples are small enough to be part of another incomplete grip in the collection (Artifact Nos. 7296-45, -84, -93, -96). All but three loose grips (Artifact Nos. 5513, 7610-1, 10098) are demonstrated to be part of complete hilt assemblies. A majority of the grips would have been associated with iron hilts and all but six of the grips are from Box 3. Sixteen grips were recovered intact including one of cast brass (Table 2), eleven are incomplete or were recovered in pieces, four were cast from concretion molds (Artifact Nos. 7296-60.2, -61.1, -61.3, -61.4), one was observed in an x-ray but too fragmentary to preserve (Artifact No. 7296-45), and one artifact (Artifact No. 7610) was unable to be examined for this study and is not categorized in regards to preservation. With the exception of the brass grip, the sword grips recovered from *La Belle* were made of machine-turned wood with the center bored out to accommodate the tang (Figure 17).

The complete, conserved wood grips ranged in length from 75 mm to 87.77 mm with an average length of 83.40 mm (Table 2). The grips are not perfectly round in cross section, but are instead akin to a rounded irregular square, with one side slightly thicker than the other. The average maximum thickness is 21.10 mm at the widest part at the center of the grip, and tapering toward both ends. All of the grips thicken at both ends where they are fitted with a ferrule to hold the ends of the wire braiding in place, then fixed to the pommel and mounted on the quillon block.

Table 2. Sword grip measurements in millimeters.

ARTIFACT NO.	LENGTH	THICKNESS 11	THICKNESS 21
1102-2	83.1	34	-
5513	95	24	-
7077-2.1	87.77	19.5	17.13
7296-4.1	87.25	20.3	16.83
7296-8.2	83.79	23.23	22.1
7296-11.2	83.75	20.39	17.35
7296-12.2	85.24	18.29	17.12
7296-13.2	83.47	20.36	14.77
7296-21.2	80.24	21.37	18.18
7296-30.2	84.95	20.11	15.92
7296-40.2	82.51	19.47	17.37
7296-50.2	77.61	23.84	22.46
7296-51.1	86.28	19.84	16.52
7296-62.3	86	20.84	16.87
11500-37	75	20	-
12930	84.0	15.0	14.0

*The dimensions of each side of the cross section of the grip at its maximum thickness.

Figure 17. Examples of wooden small sword grips, Artifact Nos.: *(a)* 7296-4.1; *(b)* 7296-21.1; *(c)* 7296-51.1; *(d)* 7296-81.1; *(e)* 7707-2. *Photo by the Texas Historical Commission.*

Figure 18. Small sword grip with silver-plated wire braiding (Artifact No.7296.50.2). *Photo by J. Kampfl*.

Twenty-three of the grips were a still associated with their pommels; the other hilt components were poorly preserved and often could not be recovered still intact. Three artifacts from Box 3 (Artifact Nos. 7296-2.2, -4.1, -73.1) were partial or fragmentary grips without pommels and three artifacts (Artifact Nos. 7296-45.1, -65.1, -70.1), also from Box 3, were pommels with fragmentary grips, possibly indicating that these groups may have been paired.

As with the grip from Box 10 (Artifact Nos. 11500-37, 12930), another grip assembly (Artifact No. 7296-50 from Box 3) consisted of a wooden core wrapped in leather, bound by silver-plated wire braiding (Figure 18). A single detached quillon block from Box 3 had remnant wire braiding in the area of the ferrule for the grip that was no longer present. Since these two artifacts are the only two from Box 3 that have evidence of wire braiding, it is speculated that these are part of the same hilt assembly (Figure 12h). Using silver or gold plating was a common practice among many metalsmiths of the period, who would then attempt to pass these off as solid silver or gold furnishings (Norman 1980:394).

The pommel of the aforementioned grip was of iron not silver plating; an indication that this particular hilt was not of overly fine quality. The rest of the grips do not bear recognizable evidence of steel wire braiding. Each of the grip assemblies discovered in the weapons box was covered with concretion and corrosion materials. Most of these were wrapped in leather and only one other grip in Box 3, Artifact No. 7296-13, had visible evidence of having wire braiding. This grip was so poorly preserved that it is not clearly defined even in the x-rays, and was therefore likely of iron.

Adding to the already poor preservation was the fact that almost all of the grips contained the corroded remains of the steel tangs which had to be removed prior to proceeding with the conservation process. The excessive swelling of the wooden grips, the result of being underwater for centuries, followed by the shrinkage caused by the dehydration process, caused the wire braiding to loosen and at times, unravel completely.

At least three of the grip assemblies (Artifact Nos. 7296-5.2, -40.2, -50.2) were found with slivers of wood wedged tightly between the inner wall of the grip and the tang, extending almost halfway into the pommel. These wooden chocks were used to secure the grip to the tang. This serves as an indication that not all of the swords acquired by La Salle were of the finest workmanship. In his first, and perhaps best known small sword treatise, *Le Maitre d'armes: ou l'exercise de l'épée seule dans sa perfection*, Liancour (1686), offers his counsel on the selection of a suitable weapon prior to engaging in fencing exercises. This is particularly interesting because Liancour's advice offers a unique insight into the manufacture, construction, and technical aspects of the small sword:

> The narrow section at the end of the blade that passes through the guard, the grip and the pommel is called the tang. To accommodate the tang, the opening through the quillon block and the pommel should be cut wide. It is better to have a large opening through the guard and pommel than to file down the tang

> to fit a small one. If the opening is too large, the Furbisher can insert small pieces of wood to make a tight fit. Be careful at this stage, for the Furbisher might file down the tang too much in order to save himself the trouble of widening the holes through the quillon block and the pommel. If he does this, no amount of wood inserted in the hollow space will give the sword a tight fit (Liancour 1686:5–6).

The French fencing master Monsieur L'Abbat is in complete agreement with Liancour, proclaiming that the selection of a proper sword is of the utmost importance:

> It would not be amiss for a Man to see his Sword mounted, because the Cutlers, to save themselves the trouble, of filing the inside of the hilts and pommel, to make the Holes wider, often file the Tongue of the blade too much, and fill up the Vacancies with Bits of Wood, by which Means the Sword is not firm in the Hand, and the tongue being thin and weak, is apt to break in Parrying or on a dry Beat, as has been unhappily experienced. Care should also be taken that the End of the Tongue be well riveted to the Extremity of the Pommel, lest the Grip should fly off, which would be of very dangerous Consequence (L'Abbat 1734:1).

A single detached grip (Artifact No. 5513) was identified as a brass grip cast to resemble a wooden small sword grip with wire braiding (Figure 19). A seam running vertically down both sides of the grip indicates it was cast in two separate pieces, then soldered together. The overall length of this grip is 95 mm. The width at its widest point at center measures approximately 24 mm. It is not uncommon to find different sword types with all-metal grips dating to the late 17th century. A saber with a brass grip is described by Michel Pétard (1995:11–14; 2006) and is identical to the one discovered on *La Belle*.

Figure 19. Brass sword grip (Artifact No. 5513). *Photo by J. Kampfl*.

Sword Blades

Liancour and L'Abbat both stressed the need for a solid, well-constructed sword hilt and blade. The most vulnerable part of any sword blade is where the tang meets the shoulder of the blade. The preferred method is to forge the tang and blade as one piece. The less desirable method is to forge the blade and weld the tang on at a later date. Any swords constructed in such a manner will not likely stand up to prolonged use. This could prove particularly troublesome during an actual duel or when the need to defend against an assailant arose.

Thirty-seven artifact lots included parts of sword blades for a combined total of 64 fragments. Thirty of these artifact lots were from Box 3 though many blades were often concreted together and/or attached to neighboring hilts. Ranging in size from a few millimeters to several centimeters, the condition of the fragments and the fact that none of them bore any discernible maker's marks or stamps made identifying the location of their manufacture impossible. The

French sword-cutlers generally acquired the blades they mounted from European blade manufacturing centers such as Solingen, Saint-Etienne-en-Forez, Franche Comte, and Toledo (Bezdek 2000; Poppensiek 1986:84–85). The physical state of the blade fragments limited the amount of recoverable data, though the conservation process and a thorough analysis of the remains still managed to yield a great deal of useful diagnostic information.

Only two blade types were subsequently identified from the surviving fragments. The bulk of these were of the diamond cross-section type, an extremely common small sword blade type; with two flat edges and a central rise or rib running the length of the blade on both front and back (Figure 20). The partial remains of one guard retained a substantial portion of the ricasso (Artifact No. 7296-45.3). Though the upper section of the blade did not survive, an acceptable cast was made of the concretion mold. The ricasso extended approximately 13.7 mm from the guard. This unique blade possessed a hollow, slightly rounded channel or fuller running the length of the blade on both sides (Figure 21). The blade remains measured 31.3 mm in length, 19.7 mm wide, with a center thickness of 4.5 mm. Several two-edged blades discovered on *La Belle* have a central ridge running the entire length of the blade (Artifact No. 7296-11.6). This ridge is a reinforced area designed to improve the rigidity of the blade.

Figure 20. Conserved small sword blade fragments with a two-edged, diamond cross section. The largest segment on the left was conserved within a section of its wooden scabbard. *Photo by J. Kampfl*.

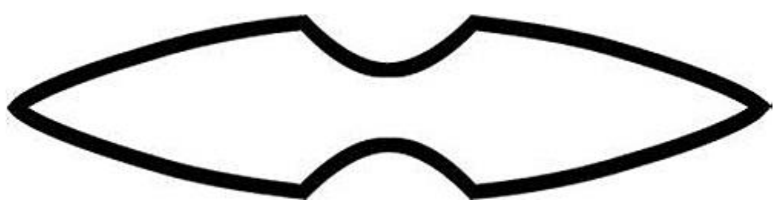

Figure 21. The cross section of a small sword blade (Artifact No. 7296-45), depicting a two-edged blade with a narrow, central fuller running the length of the blade. *Illustration by J. Kampfl.*

Sword Scabbards

Nineteen artifact lots contained a total of 90 fragments of scabbards. The scabbards were recovered in various states of decomposition. Corrosion by-products from the steel blades inside the scabbards, coupled with prolonged exposure to a saltwater environment reduced all but three of the scabbards to small pieces and fragments. Evidence would also suggest that not all of the swords were packed with scabbards. Surviving remarkably well preserved, the first scabbard (Artifact N0.7296-54.1) measured approximately 310.5 mm in length, an average width of 44.3 mm, and an average thickness of 24 mm. The second scabbard (Artifact No. 7296-55.1) measured 393 mm in length, 35.2 mm wide, and 24 mm thick. The last of the three scabbards (Artifact No. 7296-11.7) measured 210 mm in length, 20 mm wide, and 24 mm thick (Figure 22).

Figure 22. Views of a small sword scabbard, Artifact No. 7296-11.2: *(a)* exterior; *(b)* interior. *Photo by J. Kampfl.*

All three of the scabbards were constructed using the same production methods: with two or three strips of wood per side glued together. As a result of their prolonged exposure to the undersea environment, the wood of the scabbards began to swell and come apart with the individual strips of wood peeling away. Once the front and back of the scabbard are made, both sides are cut to shape around the sword blade, narrowing somewhat toward the scabbard tip. After the two sides are fixed together, the scabbard body is covered with some type of textile or other organic material (Figure 23). Remarkably, remnants of the textile covering used on all three scabbards survived, though the remnants were badly stained by iron corrosion deposits (Figure 24).

Figure 23. Prolonged exposure to an underwater environment caused this small sword scabbard to come apart, revealing the blade within and the wooden strips used to fashion the scabbard (Artifact No. 7296-11.2). *Photo by J. Kampfl.*

Figure 24. Section of a small sword scabbard bearing remnants of a textile covering; probably a plain woven linen fabric (Artifact No. 7296-11.2). *Photo by J. Kampfl.*

Metal scabbard mountings were fitted to the scabbard completing the assembly process (Pétard 1987:9–10). Only four scabbard chapes were identified (Artifact Nos. 2371-3, 11500-3, 7296-33, -55.3). An extremely well-preserved chape (Artifact No. 11500-3) was extracted from Box 10 (Figure 25). The chape measured 66.8 mm in length; the mouth measured 15.6 mm × 11 mm. Artifact 2371-3 is complete but slightly damaged. It measures 65.6 mm in length with a mouth 15.4 mm wide. Two chapes (Artifact Nos. 7296-33.7, 7296-55.3) were observed in Box 3, though the preservation was extremely poor and ultimately they could not be conserved. Artifact No. 7296-33.7 measured approximately 80 mm in length, with the mouth measuring 16.5 mm × 10 mm. The partial remains of another brass chape were discovered still mounted on its scabbard (Artifact No. 7296-55.3). All of the surviving scabbard chapes are made of brass and were fabricated using the same technique. A small piece of sheet brass would be bent and shaped using a mandril and small hammer. A thin vertical seam is visible where the metal meets forming the small cone-shaped fitting.

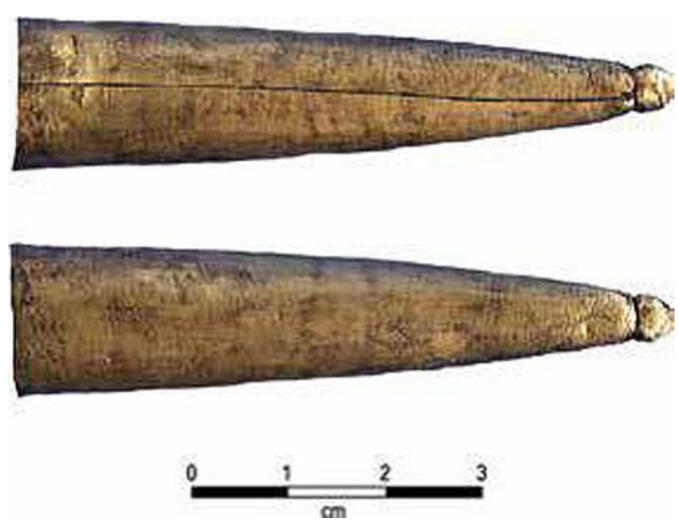

Figure 25. Brass small sword scabbard chape: front *(top)* and back (Artifact No. 11500-3).
Photo by J. Kampfl.

Three brass scabbard hooks (Artifact Nos. 4067, 7142, 7955) were identified (Figure 26). Artifact No. 4067 measures 62 mm in length and 30 mm at its widest point and Artifact No. 7142 measures 67 mm in length and 26 mm in width. Artifact No. 7955 is incomplete. This particular style of hook would have been attached to the upper portion of the scabbard by sliding it over the scabbard mouth with the long end extending outward and down. The metal throat would then be placed over the scabbard mouth, securing the hook firmly in place. A scabbard hook was used in conjunction with carrying rings to suspend the scabbard and sword from either a baldric or belt.

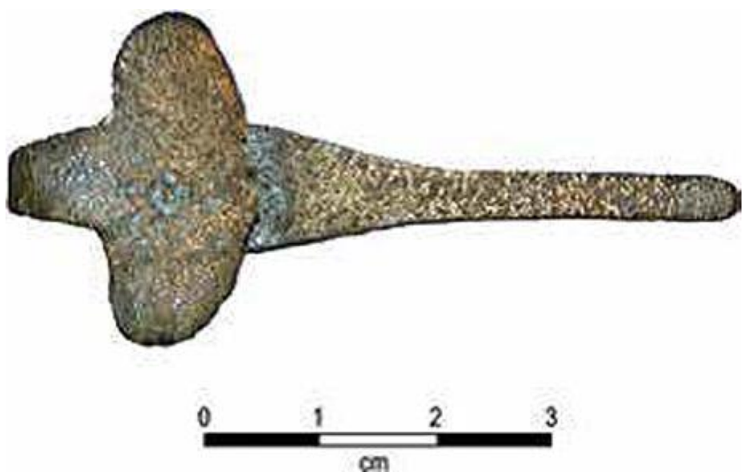

Figure 26. Front and rear view of a brass small sword scabbard hook (Artifact No. 4067). *Photo by J. Kampfl.*

Summation

With two exceptions, all of the swords discovered on *La Belle* appear to be of the small sword type and are uniform in size and style. The only indications that swords not of this type were on *La Belle* was the discovery of an incomplete partial sword hilt, possibly belonging to a cutlass or simple saber (Artifact No. 3493), and a saber hilt (Artifact No. 12930). A majority of the sword hilts from *La Belle* were made of iron. These military swords therefore conform to the quality of weapons provided to the common soldier. It is most likely that these swords were mass-produced and acquired by La Salle in bulk numbers, which is furthermore implied by the royal arsenal as the source of the weapons. The presence of both small swords and a saber in the collection conforms to the types of edged weapons granted to La Salle by Louis XIV.

Though many of the swords appear to have been lower-quality, infantry-type weapons, a couple of artifacts are distinct due to their ornamentation or size. It is possible that the exceptional small sword hilt of brass and incised decoration (Artifact No. 1102) belonged to one of La Salle's officers; however without reliable documentary or physical proof, there is no way to substantiate such a claim. This particular hilt was discovered packed away with other weapons, in Box 3 (Franklin 1996).

A second brass hilt sword hilt (Artifact No. 11500-25, -36, -37) is also a curiosity in that it is much smaller than what was typical, leading to speculation that it may have belonged to child. The length of the grip, however, is within the range of examples associated with "adult" swords and the intricacy of the wire braiding exceeds all other examples from the shipwreck. Since it was located in a box of mixed materials and tools (West 2017:636-659), it has been presumed this was a personal item. The unique size and complexity of the grip may suggest it once belonged to a more affluent member of the expedition and it may have been custom-made and not necessarily a child's fencing weapon.

The loss of weapons and other materials during the attempted off-loading of stores from the ship as it sank partially explains why the number and types of swords discovered on *La Belle* did not match the expedition's supply list. Swords may also have been among the items lost on *L'Aimable* when it wrecked in Pass Cavallo in 1685. Written sources also indicate that prior to setting out in search of the Mississippi River, La Salle ordered provisions, equipment, and weaponry to be sent ashore to aid in the building of Fort St. Louis. Henri Joutel (1998:111) records that La Salle left him in command of the fort along with a considerable amount of provisions and an inventory of building materials and weapons including 200 sabers and swords, referred to as “cutlaces” in an early English translation (Joutel 1896:56) of a version of Joutel’s diary. In their interview with French authorities, Jean-Baptiste and Pierre Talon, both of whom served under La Salle, recounted that the men in La Salle’s exploration parties were always armed with “sabers or straight swords” (Talon and Talon 1987:227).

Noticeably absent from the written and physical records were bayonets. Early bayonets consisted of a blade and handle, also referred to as a plug. The plug bayonet could effectively turn a musket or flintlock into a pole weapon; the obvious drawback being that the musket or flintlock could not be fired or reloaded quickly while the bayonet was still lodged in the barrel. Near the end of the 17th century, the armies of Europe were slowly being outfitted with socket bayonets, invented in 1687, which could be attached to the barrel without blocking the muzzle (Chartrand 2005a:18, 21). This type of bayonet was not fully adopted by the French Army until 1703, although the French colonial troops were generally issued bayonets (Evans and Stephens 1985; Thompson 1999:59–77).

The military capabilities of the small sword are often underestimated. The evidence discovered on *La Belle* indicates that the small swords stored in Box 3, the weapons crate, were of iron with one example of solid, cast brass construction. The steel, double-edged blades and tangs were forged as one, giving them strength and durability. Most of the sword hilt components appear to have been manufactured en masse; the components and finished hilts being assembled and decorated individually at a later date. Though the array of edged weaponry discovered on *La Belle* was not overly extensive, the swords and sword-related artifacts excavated from *La Belle* offer a unique opportunity to study these fascinating weapons. The conservation effort of these swords, discussed in the next chapter, will not only elucidate the necessary applications of science in order to preserve these remarkable weapons, but will also shed new light on their material makeup and the techniques used in their manufacture.

CHAPTER V

CONSERVATION OF SWORDS FROM A MARINE ENVIRONMENT

This chapter examines the processes involved with developing and implementing a sound conservation plan for each of the swords recovered from *La Belle*. For over three hundred years the remains of *La Belle* and her cargo lay submerged and buried in sediments of Matagorda Bay. Sinking slowly, landing upright on the Bay floor, and quickly covered by sediment, *La Belle* was spared most of the physical damage caused by ocean tides, currents, and violent storms, which can wreak havoc on a shipwreck site in the open Gulf of Mexico, displacing or destroying the remains of a ship and its cargo. Fortunately, the hull of *La Belle* did not sustain much physical damage as a result of its sinking in the shallow depths, with layers of sediment covering the wreck over time, offered some measure of protection against the damaging chemical and biological agents of a marine environment.

As the excavation of the *La Belle* progressed, four wooden boxes were discovered deep within the main hold of the ship; located near the starboard side mid-ship, stacked two on two resting against the bulkhead of the ship's hull (Bruseth 2005:94-95) (Figure 27). The initial documentation and extraction of the four boxes (Box Nos. 2, 3, 5, and 6) took place over a two week period from late November to early December in 1996 (Cook 1996). Archaeologists working on site removed a substantial layer of ocean sediment from around the weapons boxes revealing a thick, extremely hard layer of encrustation encasing the boxes and exposed artifacts (Figure 28). These layers were carefully removed so the condition of the boxes and the artifacts within could be assessed. The relevance of encrustation to the conservation process will be discussed later.

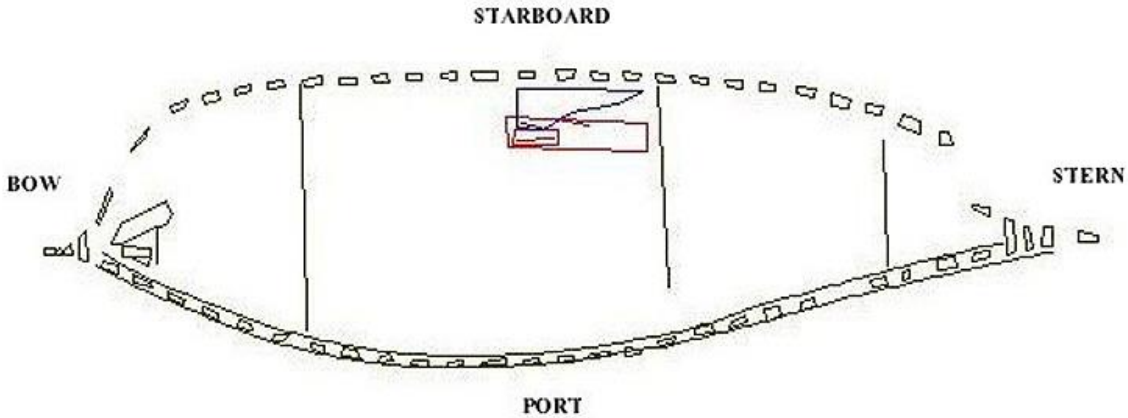

Figure 27. *La Belle* hull diagram indicating the positions of the four weapons crates. Box No. 3 (Artifact No.7296) is outlined in red. *Illustration by G. Cook. Courtesy of the Texas Historical Commission.*

Figure 28. Photograph of weapons Box Nos. 2 (left) and 3 (right), lying *in situ* on the starboard side of the *La Belle* shipwreck. *Photo courtesy of the Texas Historical Commission.*

It was soon discovered that the boxes held an impressive collection of flintlock muskets and sword related artifacts. Three of the four wooden boxes were incomplete; however Box No. 3 (Artifact No.7296) remained relatively intact containing a number of well-preserved musket stocks and the exposed bronze hilt of a small sword (Artifact No.1102) (Figure 29). Rather than disassemble Box No. 3 *in situ*, the entire box and its contents were lifted from the remains of the wreck, and transported to the Conservation Research Laboratory at Texas A&M University.

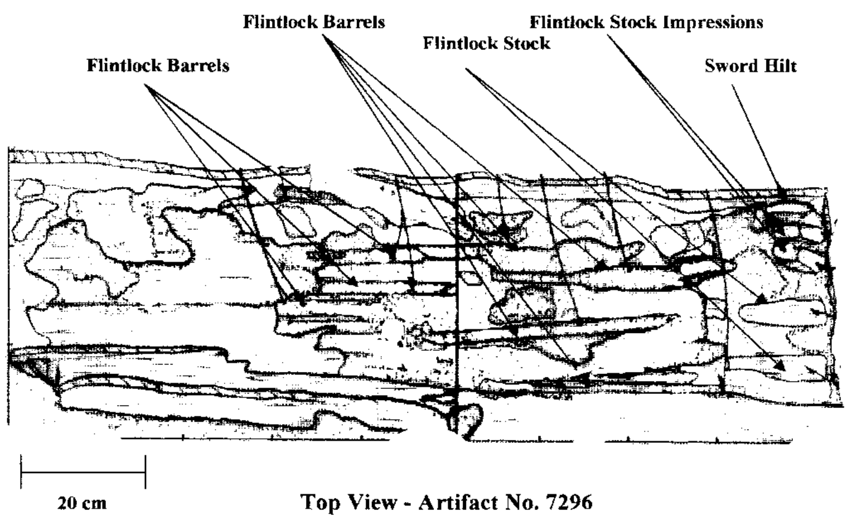

Figure 29. Diagram of Box No. 3. Top view with the lid removed revealing the wooden stocks of muskets and the remains of a brass small sword hilt. *Illustration by G. Cook. Courtesy of the Texas Historical Commission.*

The box, constructed of white pine, measured approximately 210.4 cm in length, 50.1 cm wide, and 42.2 cm from top to bottom. The upper portion and sides of the box were heavily concreted and all of the weapons in the box were packed tightly in straw and other grassy materials. Following an extensive documentation process, the concretion and packing material was carefully removed using an air scribe. This particular box contained several tightly packed muskets and swords. Bits and pieces of textile were discovered adhered to the surface of several swords and muskets. Whether this textile was used to wrap the weapons individually or used to cover the entire contents of the box is still in question. The artifacts were then placed in proper fresh water storage until the conservation process could begin.

Though the exterior of the boxes may be afforded some protection by the layers of sediment and concretion, the interior of the wooden boxes excavated from *La Belle* represent an isolated micro-environment or an enclosed system. The material make up and overall condition of the artifacts prior to the shipwreck, the proximity of the artifacts to each other, and the structural integrity of the box itself localizes the chemical and biological changes affecting the artifacts within. Once the integrity of this enclosed system is compromised, its internal matrix will begin an immediate transformation. The integrity of this enclosed system can be compromised by the natural forces surrounding it under the ocean, or during an archaeological excavation, in which case the artifacts must be extracted, immediately stabilized, and placed in proper storage until conservation.

Following their removal from the box, the sword remains were carefully examined and the condition of the component materials thoroughly assessed before conservation could begin. The processes of corrosion and organic decomposition are fairly complex and will be discussed in-turn, as will the conservation procedures employed to stabilize and preserve the sword remains.

Metal Conservation

Iron

All chemical reactions involve the breakdown and reformation of chemical bonds of molecules to form different substances. The composition, structure, and properties of the artifacts will undergo extensive chemical changes on a molecular level. These changes will either aid in the preservation of the physical state of an artifact, or accelerate its molecular breakdown, destroying important archaeological data.

Perhaps the most harmful chemical reaction associated with iron is corrosion. Corrosion is a chemical or electrochemical process, which causes the deterioration or destruction of a material as a result of its interaction with its environment, in the case of the *La Belle* swords, salt water. The primary metals used in the construction of the *La Belle* swords are iron and the alloy brass. Iron does not occur naturally in its pure, uncombined metallic form in the Earth, but is most abundant in combination with other forms, such as oxides, sulfides, carbonates, and silicates. Easily oxidized, metallic iron reacts directly with many non-metallic elements forming compounds in which iron is in the +2 Ferrous or +3 Ferric oxidation state.

The corrosion of metal in a marine environment is essentially an electrochemical phenomenon. In most instances three chemical components must be present for iron to corrode: oxygen, water, and an electrolyte (Robinson 1982:221-231). Other variables that affect the corrosion rate of iron in a marine environment are: temperature, water velocity (the movement of the water removing protective oxide films), the amount of oxygen in the water, the pH level, the proximity of other artifacts, the presence of aggressive anions like chloride, and if the iron exists in an anaerobic environment, the presence of sulfate-reducing bacteria (Peterson 1969:30;

1972:244; Hamilton 1996:42-47). Corrosion will also occur along mechanical stress lines created, as in the case of the swords, by the forging and metal fabrication processes, which makes the stressed metal more anodic to the rest of the metal and corrodes at a preferentially accelerated rate.

Impurities in the iron ore and the degree, to which the ore has been worked, will also influence the rate at which iron artifacts corrode. Iron artifacts recovered from a saltwater environment are generally converted to one of four types of corrosion products: ferrous sulfide (FeS), magnetite (Fe_3O_4), ferrous hydroxide (Fe (OH)2), and a range of iron chlorides (MacLeod 1989:7-16; 1997:331-353; Hamilton 1996:46). When the iron object begins to revert to magnetite, an oxide film slowly forms around the object stabilizing it to some degree, allowing the object to retain some vestige of its original form and features (Stambolov 1985:120-122).

Electrolytic corrosion is a complementary process in which an anodic (oxidation) and cathodic (reduction) reaction occurs, resulting in a flow of electrons from one location to another. This flow of electrons creates an electric current between two dissimilar metal surfaces, and even between different areas of the same metal object, and an electrolyte solution creating an electrolytic cell. Oxidation is the process of losing electrons, while reduction is the process of gaining electrons. In essence, a base metal will sacrifice itself so that a more noble metal might survive even within the same metal object (Figure 30).

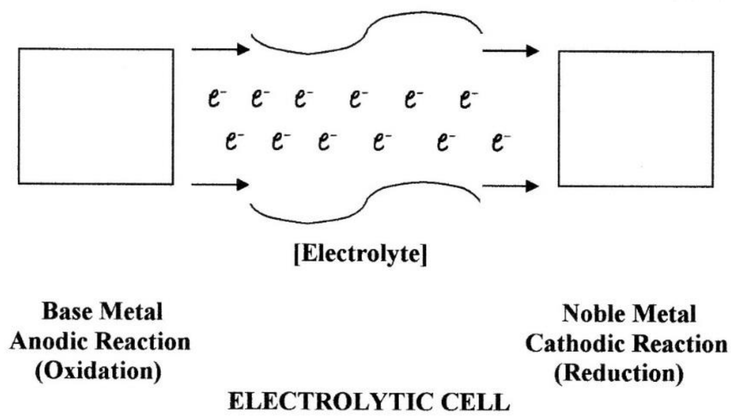

Figure 30. Diagram showing a simple electrolytic cell. *Illustration by J. Kampfl*

Galvanic corrosion is an electrochemical process which occurs when different metals, with significantly different electrochemical potentials are immersed in an electrolyte, such as sea water. Galvanic corrosion can also occur when different areas on the same metal are brought into contact. Direct contact between the metal surfaces forms an electrical contact, in effect generating an electrical current (potential) through an external circuit (Goffer 1980:257). Galvanic corrosion is particularly problematic when dealing with composite artifacts, *i.e.* an iron or steel sword blade attached to a brass hilt. In this case, the iron is anodic to the brass hilt and gives up its electrons to brass, which protects it from corroding. In order to corrode a metal has to use electrons, if a metal receives electrons, it is protected.

Metal Alloys

The sword hilts and metal scabbard fittings removed from Box No. 3 were all made of brass. Brass is a cupreous alloy consisting mainly of copper (over 50%) and zinc. Other elements such as tin and lead are added to copper in making brasses, depending on the color, strength, machinability, corrosion resistance, and ductility desired. Brass, used extensively to fashion sword fittings, was relatively cheap because it was easy to cast and easy to tool.

The two most common types of copper corrosion products produced by cupreous alloys exposed to a marine environment are cuprous chlorides and cuprous sulfide. Bronze disease, a particularly destructive type of corrosion, occurs when cuprous chlorides react with water and oxygen to hydrolyze, forming hydrochloric acid and cupric chloride. The HCl attacks the uncorroded metal forming more cupric chlorides until all of the metal has been eaten away.

When attempting to conserve chloride contaminated cupreous artifacts, three important steps must first be taken: all cupreous chlorides must be removed prior to treatment, the cupreous chlorides must be converted to innocuous cuprous oxide, any further chemical action, or reaction from the chlorides must be prevented by protecting the object from the atmosphere (Hamilton 1996:89-91). Although cuprous based metals are more noble than iron, they must be properly stored and conserved utilizing proper conservation treatments.

Organic Artifacts

Most of the sword grips and all of the scabbards removed from Box No. 3 were made of wood. Waterlogged wood generally refers to a wooden artifact that comes from a wet archaeological site or even wood buried in wet soil for a lengthy period of time. Like metal, wood and other organic objects are subject to physical, chemical, and biological agents capable of causing great harm to the artifact. As with metal, there are a number of variables that determine the degree to which an object constructed from wood might be damaged. The same undersea conditions which could prove harmful to an object made of metal, might possibly offer a degree of protection to a wooden artifact (Hamilton 1996:25; Unger 2001:43).

The conservator must possess some knowledge of the different wood types and species before a conservation plan can be implemented; the type of wood and the condition of the wooden object prior to being submersed play an important role in its ability to survive an undersea environment. Care must be taken to keep organic materials wet, even while working on them.

The most important step in waterlogged wood conservation is the removal of the water, using a process by which the wood does not shrink or warp. The conservator must also take care to prevent the wood from drying as this will cause it to expand, split and crack. If the object is from a marine environment the chloride content, in the form of soluble salts must also be carefully removed without damaging the wooden artifact. Quite often, even severely waterlogged wood will appear to have retained its form and structure. This is misleading as over time water will displace the important soluble chemicals that support the cell walls of the wood. The wood appears sound, but the internal matrix, consisting of lignin, cellulose and hemicellulose has been compromised by the water, leaving the object sponge-like and easily damaged if handled inappropriately.

Hydrolysis is a chemical reaction in which water is one of the reactants. In the case of waterlogged wood, it is a decomposition process in which water will break down wood tannins and cellulose, leaving only a lignin framework to support the cell walls. Lignin is a complex natural polymer that provides support and protects the cells. Over time, the lignin will begin to break down, and the wood becomes even more waterlogged. The wooden object retains its basic shape, though the excess water will cause the object to swell, while maintaining the overall shape of the wood (Sjostrom 1993:229).

Swelling caused by water absorption became a serious problem when trying to remove the metal wire from around the wooden sword grips; the metal wire boring deep into the swelling wood was extremely difficult to remove without damaging the grip. It is possible to conserve the metal and wood together reducing the risk of harming either material. This process will be further discussed in the following pages.

As with wood, any surviving textile material must be properly identified and its condition assessed prior to implementing any conversation procedure. The term textile applies to a wide range of products generally woven out of materials grown or harvested for such a purpose. Like wood, the textiles of the early modern period were all made of organic materials, and also like wood, textiles are susceptible to a wide range of organic, physical, and chemical agents that cause irreparable damage to textile fibers (Hamilton 1996: 37).

The only textile associated with the sword finds was the cloth used to cover the scabbards. The cloth used to cover the wood scabbards was identified as linen; a yarn or woven fabric made from the inner bark of the flax plant. Great care must be taken to prevent any waterlogged textile from drying out before it can be stabilized. The fibers of the cloth will become brittle and begin to unravel, destroying the article (Baines 1985).

Composite Artifacts

Complicating matters further, the swords and muskets within the wooden box are composite artifacts. Composite artifacts are composed of two or more material classes and present a unique set of conservation problems discussed below. Many different material types are used in the construction of the swords; wood scabbards and sword grips, textile scabbard and grip covers, brass hilts and scabbard fittings, silver grip wire, and iron sword blades.

Artifacts retrieved from a marine environment are often covered with encrustation. The chemical and biological composition of the surrounding marine environment react with metal corrosion and decomposition by-products, forming layers of concretion (Leigh 1973:203-218; Florian 1987:120; Hamilton 1996:6, 45; Hamilton et al. 2017:60-80). The encrustation can range in thickness from a few millimeters to several centimeters depending on the size of the object. Though encrustation can prove very difficult to remove the formation of these concretions can in-affect, aid in the preservation of certain types of artifacts. The rapid corrosion of ferrous objects can create a 'concrete-like' covered void or mold of any artifact that was once covered with marine calcareous concretion, preserving morphological data that might have been otherwise lost. The surface details of the now long gone artifact, are preserved in the encapsulation concretion.

This type of encrustation can aid in the preservation of non-ferrous metals and organic materials, however the opposite can occur as the organic and inorganic materials of encrusted composite artifacts will begin to adversely affect one another (Cronyn 1990:181). As wood begins to decay, it depletes the surrounding oxygen supply creating an anaerobic environment. This environment produces sulfate-reducing bacteria which hastens the reduction process of nearby metal objects, especially those made of iron, silver, and lead (Hamilton 1996:47).

Metal corrosion products can stain organic materials, and the metal chlorides will cause cellular break-down, accelerating the decay of wood and other organics (Macleod 1989:7-16; 1997:331-353). Removing an iron tang from a wooden grip of a sword becomes a complex process as the iron corrosion products will often permeate the wood, making an extraction of the tang without damaging the wood extremely difficult (Figure 31). These conditions also make any attempt to determine the exact condition of an encrusted artifact extremely difficult, even with the aid of x-ray technology. In regards to the swords, methods of removing the encrustation were determined by the thickness of the concretion, and the type and condition of the artifact (Hamilton 1996:53-54). The real challenge to the conservator is the separation of the separate components without causing more damage to the artifact.

Figure 31. An encrusted wooden small sword grip and attached brass pommel (Artifact No. 7296-21). Note the remains of the iron tang visible within the pommel. *Photo by J. Kampfl.*

Initial Artifact Assessment and Documentation

The basic criteria and procedures for determining the documentation methods and conservation treatment of underwater material culture are thoroughly discussed in several comprehensive works on the subject (Pearson 1987; Hamilton 1996; Robinson 1998). There is also a wide body of available literature which discusses all aspects of archaeological conservation in general (Cronyn 1990; Oddy 1992; Caple 2000:37-41; Keene 2002; Rodgers 2004). Since the focus of this dissertation was the swords and related artifacts, the conservation of the muskets extracted from Box 3 is not discussed here.

The box containing the swords was stored intact in a tank filled with fresh water. Following the extraction of the weapons from the box and during the preliminary documentation process, the individual artifacts were placed in containers filled with tap water and an appropriate inhibiting agent (Hamilton 1996:9). Any encrustation covering the artifact was left in place to further inhibit corrosion, material degradation, and until a proper radiographic evaluation was made of the artifact's condition; reducing the chance of irreparable damage to the object.

Iron Artifacts

All iron artifacts and composite artifacts with iron components were stored in a 5% sodium sesquicarbonate [$Na_2CO_3 \cdot NaHCO_2$] and DI H_2O chloride reduction solution. As discussed in chapter four, 38 sword blade fragments were recovered from Box 3. Fourteen blades fragments did not survive, but left behind encrustation molds. These were cast using GE RTV-112, a self-leveling rubber adhesive (GE Silicones). The casts were extracted from the molds and mechanically cleaned. The 25 surviving iron blade fragments retained much of their original shape, but the iron content had been reduced to magnetite. Following a minimum amount of mechanical cleaning, the blades were prepared for a series of sodium sulfite bath treatments. The sodium sulfite treatment was selected for several important reasons. The fragile condition of the blade fragments meant that a more passive conservation treatment was necessary for a favorable outcome. The sodium sulfite treatment consistently achieves positive results with a minimum expenditure of time and materials.

The blades were immersed in a mixture of sodium sulfite [$Na_2S_2O_4$], sodium hydroxide [NaOH], and 1 liter tap water. It is important to maintain an airtight seal of the container to avoid solution oxidation. The containers were placed in an oven and heated to a temperature of 52º Celsius. Over time, the heated solution becomes discolored and saturated with chlorides drawn from the blade fragments. Each iron piece was carried through a series of sealed baths until no discoloration, indicating the presence of iron, appear in the final sodium sulfite-sodium hydroxide bath. This indicated that the chlorides and the corroded iron magnetite had been removed. The size and condition of the artifacts determines the treatment time and how often the solution must be replaced with a fresh mixture and heated again. Following the final bath, the iron objects were placed in a bath of DI H_2O overnight and then tested for chloride content using the silver nitrate method. Using the silver nitrate test requires it be done in an acidic aqueous solution.

The sword blade fragments underwent a total of three sodium sulfite baths before the chloride content was deemed low enough to proceed with the next step. Once the fragments were stabilized, they were thoroughly rinsed with DI water. Immediately upon removal from the DI water rinses each fragment submerged in a solution with 20% tannin solution. Each fragment was allowed to dry before the next application of tannin solution. Following the final application of the 20% tannin solution, the fragments were allowed to thoroughly dry over a period of several days. This allows the tannic acid to react with the iron residue and oxidize to form Ferric Tannate, which makes any remaining iron more corrosion resistant.

The final conservation step involved the immersion of the fragments into a molten bath of microcrystalline wax. The microcrystalline wax served as an excellent sealant against further corrosion. The blades remained in the molten wax for a period of several days or until they stopped emitting oxygen bubbles, indicating the complete penetration of the wax into all the porous areas of the blade fragments. The Witco 90 wax melts at 90◦ C. The temperature of the wax is then raised to 150◦ C in order to vaporize any remaining moisture lingering in the minute holes and crevices of the fragments. On the last day, the blade fragments are removed after allowing the wax to cool down to a temperature of 94◦ C. After the excess wax was removed, the fragments were prepared for storage (Figure 32).

Figure 32. Iron blade fragments before sodium sulfite treatment (left) and after (right). These fragments survived the treatment extremely well, remaining intact and retaining their original size and shape. *Photos by J. Kampfl.*

Brass and Cupreous Artifacts

Since there are several treatment options for brass or objects made of other cupreous alloys, the condition and material makeup of the artifact would determine the conservation treatment to be used. All of the brass sword components were safely stored in a 5% sodium sesquicarbonate [$Na_2CO_3 \cdot NaHCO_2$] and DI H_2O chloride reduction solution until the documentation and conservation processes could begin. The larger solid brass artifacts were mechanically cleaned of encrustation and corrosion products, and then subjected to a period of electrolytic reduction cleaning in a 2% sodium hydroxide solution. Before electrolytic reduction could begin, all of the organic hilt components were removed and treated separately (Figure 33).

The electrolysis setup for the brass sword components consisted of a 2% sodium hydroxide [NaOH] solution acting as an electrolyte, a mild steel anode, and a DC power supply. The size, condition, and material makeup of the object determined the length of treatment and the amount of current utilized during the process (Hamilton 1996:56-60). The process always begins at a reduced current level and increased slowly over a period of time in order to minimize any potential damage to the artifact. Chloride levels in the solution were measured every second day using the standard mercuric nitrate test.

Following electrolysis, the objects were subjected to a series of boiling deionized water rinses to facilitate the removal of all sodium hydroxide residue. The artifacts were then examined and any remaining residue removed with a fiberglass brush and baking soda. The final treatment involved the complete immersion of the artifacts in a bath of 3% BTA [benzotriazole]. The BTA bath and a final coat of Krylon Clear Acrylic 1301 spray aided in the stabilization of the object and protected it against atmospheric moisture and other harmful elements.

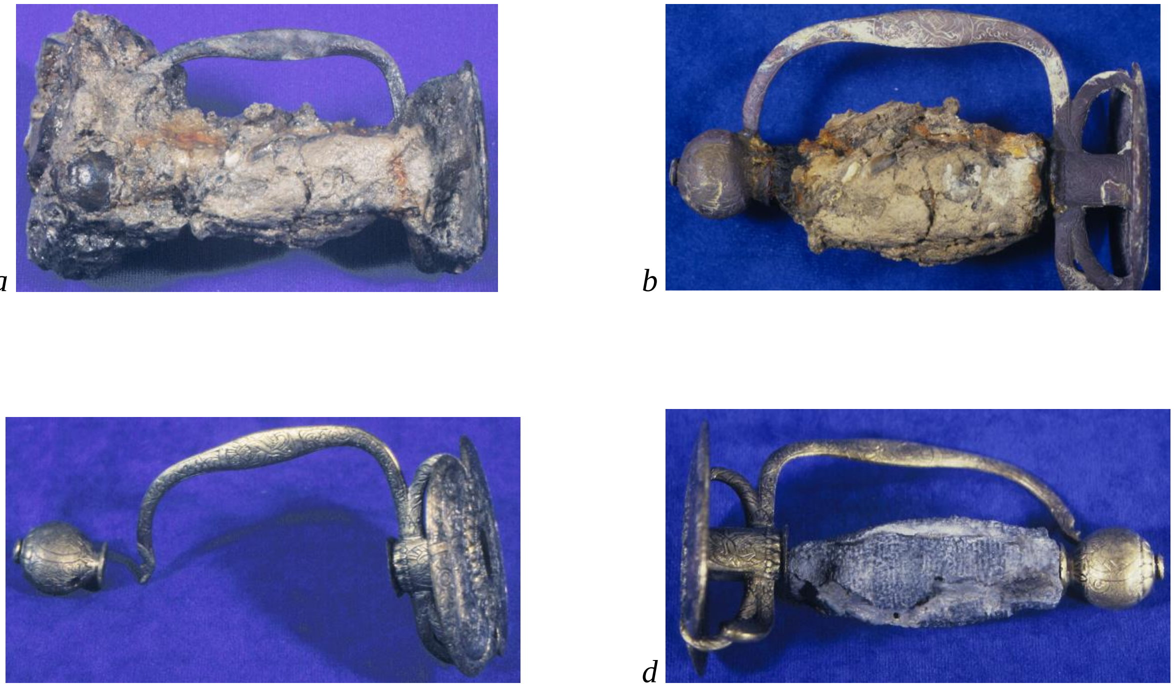

Figure 33. *a, b*) A brass small sword hilt (Artifact No.1102) as it undergoes mechanical cleaning to remove encrustation deposits. *(c)* The hilt following electrolytic reduction.
(d) The wooden grip was removed prior to ER, conserved separately using the acetone-rosin method, and reattached after the hilt's final treatment. *Photo by J. Kampfl*

Other conservation treatments had to be considered for more fragile artifacts. A brass guard [Artifact No.7296-22] was discovered in extremely poor condition (Figure 34). Most of the guard was reduced to a brittle, heavily encrusted mold, outlined by thin traces of brass. Following an extensive documentation process, the trace elements of brass were removed. The rest of the guard was thoroughly cleaned with tap water and a soft toothbrush. The entire guard was then cast using GE RTV-112, a silicone-rubber, with excellent results. The detail of the guard's decoration and other diagnostic data were preserved, though the artifact did not survive the casting process.

a

b

Figure 34. *(a)* The remains of a brass small sword guard (Artifact No.7296-22) prior to mechanical cleaning. *(b)* The same guard following mechanical cleaning and the removal of all brass trace remains. The remains of the guard were cast using RTV-112, preserving the detail of the original decoration. *Photo by J. Kampfl.*

A single large encrustation contained the remains of two small sword hilts, and the upper section of both blades [Artifact No.7296-10 and 7296-11]. X-rays revealed that very little of either hilt remained intact, though the encrustation had formed a nearly perfect natural mold around both artifacts (Figure 35). Because of the way the hilts were arranged in the crate, encrustation only covered one side of both hilts, while the other, being partially protected from the elements by the other weapons, was reduced to a soft mixture of wood and metal corrosion products. This made the removal of the debris easier, but only allowed for a partial cast of the original artifact.

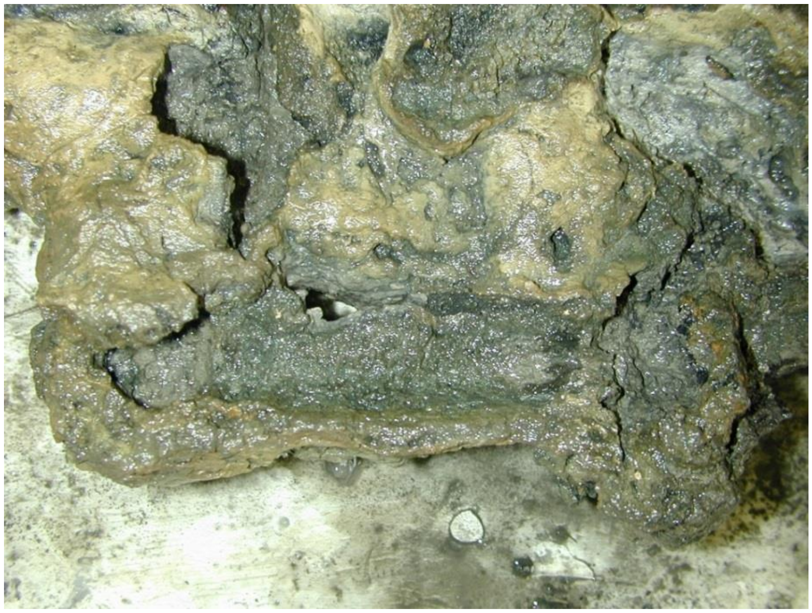

Figure 35. The natural mold of an encrusted small sword hilt (Artifact No.7296-11), following mechanical cleaning and the removal of corrosion products and other debris.
Photo by J. Kampfl.

Both molds were thoroughly cleaned and prepared for casting by building a clay dam around the outside of edge of the encrustation mold to contain the casting material. A thin coat of Pam cooking spray was applied to the surface of the mold to facilitate the extraction of the completed cast later. Since it was not necessary to protect any surviving hilt components, and the mold was rather large, it was decided that Hysol RE2034 epoxy would be used to cast the mold.

Hysol, formerly manufactured by the Dexter Chemical Company, is an epoxy resin, which must be mixed using a 100/30 mixture of epoxy resin (RE2039) and hardener (HD3561). This mixture is poured directly into the mold and allowed to cure at room temperature. As the epoxy cures, it has a tendency to shrink slightly so more epoxy can be added as necessary (Figure 36).

The results were exceptional; the casts preserving the general shape and dimensions of both hilts, incised decorative patterns of the guards and pommels, and the impressions of the wire braiding, which once wrapped around the wooden grips. The casts required a minimum amount of mechanical cleaning to remove small amounts of encrustation and debris (Figure 37). The diagnostic information was recorded and the casts appropriately documented and stored.

Figure 36. The Hysol resin epoxy used to cast the encrustation mold as it begins to set. The clay dam surrounding the cast prevents the epoxy from leaking onto the rest of the encrustation, and allows for the addition of more epoxy if necessary. *Photo by J. Kampfl.*

Figure 37. The completed Hysol cast after mechanical cleaning and the removal of the encrustation. Closer inspection of the mold reveals the details of the guard decoration and grip wire braiding. *Photo by J. Kampfl.*

Several of the surviving wooden small sword grips had the remains of metal pommels still attached to them (Figure 38). Separating the encrusted pommel remains from the wooden grip was risky, as the encrustation mold of the pommel might be damaged or the wooden grip torn or split. Since the wooden grip had to be kept wet at all times, work on removing the encrustation and corrosion products from the pommel cavity proved an arduous task. If the actual pommel did not survive the natural encrustation mold could be cast. Since the organic hilt components had to remain wet the decision was made to cast the pommel using Bio-Seal Marine Epoxy.

Figure 38. A small sword grip (Artifact No.7296-40.1) with the encrusted remains of the pommel still attached. The pommel cavity has been cleaned of all debris and is now ready to be cast. *Photo by J. Kampfl.*

Bio-Seal is a solvent free, solid epoxy, which when mixed with a special hardening agent, has the ability to cure underwater. After the epoxy is poured and allowed to set for a short amount of time, the entire artifact can be placed back in the water keeping the wooden grip safe and intact. The cast, which takes on a light amber color after it has cured, is easy to clean and accurately retains the decorative detail of the original pommel. If great care is taken the encrustation mold of the pommel can be removed prior to conserving the wooden grip. The mold, if intact, can be recast or discarded after it has been thoroughly documented (Figure 39).

Figure 39. A small sword grip (Artifact No.7296-12.1) following the casting of the pommel. In this case the pommel, cast with Bio-Seal epoxy, was removed prior to the conservation of the wooden grip. *Photo by J. Kampfl.*

Wood, Textile and Composite Remains

All of the wooden grips and scabbards were covered with various thicknesses of concretion and iron corrosion products. The hollow core of each sword grip was filled with the corroded remains of the iron tangs. The tangs were mechanically extracted using dental tools and syringes filled with tap water. The grips were then immersed in a bath of highly diluted 10% hydrochloric acid to aid in the removal of any remaining calcareous corrosion products. Great care had to be taken with the wood grips still wrapped by metal wire. Many of the scabbards were discovered with the metallic remains of the iron blades still inside. If intact, the blades were carefully removed and conserved separately.

After the removal of any adhering encrustation and corrosion products the wooden objects were submersed in fresh and de-ionized water to remove any remaining chlorides. The wooden objects were then subjected to a series of dehydration baths (Table 3). The alcohol baths facilitate the removal of water and chlorides from the wooden objects. The alcohol baths allow for the gradual removal of all moisture, protecting the cell walls of the wood from collapsing, causing irreparable damage to the artifact. Immediately following the final dehydration bath, the wooden objects were prepared for the silicone oil treatment.

Conserving the composite artifacts without separating the components is possible, but must be done with extreme caution. Certain types of conservation treatments for wood, such as PEG, are extremely corrosive to metal. The problems of using PEG to conserve waterlogged wood have been known for some time (Munnikendam 1973:97-99; Argyropoulos 2000:253-264). If ER is used to stabilize the iron elements of the sword and sword scabbard without removing the organic materials, the high pH levels of the electrolytic solution can accelerate organic degradation causing irreparable damage to the swords wooden components. The ongoing development and use of specialized polymers is now making it possible to conserve composite artifacts without breaking them down (Smith 2002a; 2002b; 2003).

SWORD/ARTIFACT DEHYDRATION SCHEDULE

TREATMENT	TIME
25% ETOH 75% DI H2O	3 Week Period
50% ETOH 50% DI H2O	3 Week Period
75% ETOH 25% DI H2O	3 Week Period
100% ETOH	3 Week Period
100% ETOH	3 week Period
25% ACETONE 75% ETOH	2 Week Period
50% ACETONE 50% ETOH	2 Week Period
75% ACETONE 25% ETOH	2 Week Period
100% ACETONE	2 Week Period
100% ACETONE	2 Week Period
100% ACETONE	2 Week Period

Table 3. Dehydration schedule for waterlogged wood recovered from the weapons box. All wooden objects were dehydrated using this schedule prior to silicone oil treatment.

A passivation polymer treatment, using silicone oil was developed by Dr. C. Wayne Smith at the CMAC Archaeological Preservation Research Lab at Texas A&M University. The passivation polymer treatment was developed specifically for organic and composite (organic and metal) artifacts recovered from underwater sites.

The wooden objects were completely submerged in a silicone oil solution (80%) consisting of 33% SFD-1 and 67% SFD-5. Methoxysilane/methanol, or MTSM (20% by weight of silicone oil), was added to the silicone polymer mixture to serve as a cross linker. After soaking in this solution for approximately two weeks, the objects were removed and allowed to dry over a period of several weeks. Any excess silicone solution was removed using a rag dipped in pure MTSM. The treated wood was then placed in an airtight container with DBTDA (dibutylin-diacetate), the vapors of which served as a catalyst to bond and stabilize the silicone oil molecules within the wood. The silicone oil treatment serves as a bulking agent, which preserves the integrity and shape of the wooden object. Following the stabilization period, the wooden artifacts were removed, subjected to a final cleaning, and prepared for storage (Figure 40).

The long-term goal is to conserve the wood, to preserve the shape, pliability, and surface detail of the artifacts. Evaluation of the success of this conservation technique will be determined by the artifact's diagnostic attributes, both prior to and following the conservation process: dimensional changes, weight, color, texture, pliability, and form. Other factors to be considered when determining the conservation method of a particular type of artifact would include the present state of the artifact, cost, time involved, equipment availability, reversibility of treatment, and future storage/display site.

Summation

The conservation of material culture is truly an interdisciplinary endeavor. Along with knowledge of an artifact's history and typology; an in-depth knowledge of chemistry, metallurgy, and other applicable sciences is necessary to practice conservation properly, minimizing the risk to conservator and artifact (South 1976:35-43; Morris 1980:131-136; Feller 1994:91-99; Smith 2000:3-5). Appropriate protocols must be in place for both field and laboratory conservation efforts. Artifact conservation and management procedures must constantly be reevaluated to ensure the long term stabilization and care of all material culture (Singley 1981:36-47; Sease 1994).

Figure 40. The last step of the conservation treatment is a final cleaning in preparation for storage, being performed here by the author. *Photo by J. Kampfl.*

Along with the applied sciences, "technology for conservation and analysis is increasingly becoming more a part of the conservator's job" (Anderson and Fregni 2009:95). The remains of two sword hilts, recovered from *La Belle*, were used as test subjects in three separate case studies using various x-ray modalities in conjunction with newly developed rapid prototyping technology and 3-Dimensional Imaging software applications. The results of these case studies, discussed in the next chapter, make evident the fact that these developing technologies must become an integral part of the conservator's toolbox.

CHAPTER VI

INNOVATIVE CONSERVATION AND TECHNOLOGY ADVANCEMENTS

Introduction and Project Overview

This chapter is not meant to provide the reader with a comprehensive study of the application of specific radiography and 3D printing technologies, and software packages to the conservation of objects recovered from a salt water environment. The overall purpose of my research is to build a suitable foundation on which further research into the use of current and future technologies might prove beneficial to the archaeological conservator.

Ideally, a first-rate conservation program seeks to assist both conservators and archaeologists in applying the latest technologies to the identification, treatment, conservation/preservation, organization, storage, and data management to their collections (Suenson-Taylor et al. 1999:184-194; Appelbaum 2007; Caple 2009:25-31). To a conservator technology is merely the application of science to the arts. Science and technology provide the conservator with valuable tools, which permit a better understanding of cultural resources and allows them to develop new and better treatments to conserve, protect, preserve, and at the same time, create a digital record these valuable resources (Vaccaro et al. 1996:424-450; Pye 2009:129-138). Ultimately, science and technology can provide the means by which practical solutions and techniques can be used to resolve complex problems faced by the conservator (Kotoula 2011:40).

Artifacts recovered from a marine environment pose a number of complex problems for the conservator, especially those covered with thick, extremely hard layers of encrustation. For this reason, the conservation of the swords recovered from *La Belle* was particularly challenging

(Hamilton et al. 2017:79). X-radiography is utilized extensively to identify the contents of all the encrusted metal objects recovered from *La Belle* (Bruseth 2017:xi-xii). The x-rays allowed the conservator to properly identify each encrusted artifact, analyze its material make-up, and assess its physical condition.

The physical condition of the encrusted artifact will invariably determine how the conservator proceeds with the conservation process. If enough of the artifact has survived and is reasonably intact, the conservator will attempt to stabilize and preserve the artifact by implementing an appropriate conservation plan. If all that remains of the encrusted artifact is a bit of decomposed organic matter or corrosion by-products, an attempt at casting the object must be made. As the encrustation builds up over time, it forms a near perfect mold of the artifact, preserving all the surface detail. If the mold is thoroughly cleaned of the artifact remains and other debris, an epoxy cast of the mold preserves the original details and diagnostic features of the original object can be fabricated.

Before the actual artifact can be conserved or the cast of the object removed from the mold, the outer layers of encrustation must be removed. The removal of the encrustation, whether by physical or chemical means, can be extremely hazardous, resulting in irreversible damage to the artifact and extensive data loss. This process often results in the complete destruction of the mold itself, however a silicone rubber mold can be made of the epoxy cast enabling it to be replicated. Since the artifact must eventually be either conserved or cast, it cannot remain covered with encrustation indefinitely.

The primary objective of this study is to examine new ways to extract additional data from the artifacts being studied and the benefits and applicability of computed tomography imaging and data acquisition, three-dimensional modeling software, and rapid prototyping printing technologies to artifact conservation. By combining and utilizing non-invasion radiographic and digital imaging techniques, it is possible to contribute new techniques to maximize the available data and improve upon current conservation techniques and methods. The application of these technologies will allow for faster and more reliable conservation planning and analysis, while significantly reducing the risk to the encrustation, and more importantly, the fragile artifact within and the data it contains.

Methodology and Applicable Technology

Artifact Selection

The first step required is to develop a protocol flowchart that includes all the steps involved in producing an accurate model of an encrusted artifact (Table 4). Because of time constraints and limited access to CT equipment, only two artifacts were selected as the subjects of a series of three case studies. In order to ensure that the artifacts were properly safeguarded, artifact selection was based on a pre-determined criterion (Table 5). This criteria also ensures that the material complexity and physical condition of the selected artifacts represents many of the most common problems encountered during the conservation of objects recovered from a marine environment. The heavily encrusted sword hilt (Artifact No. 12930), and the slightly encrusted small sword grip and pommel (Artifact No. 7296.12.1), both previously discussed in chapter four, will serve as the test subjects for the following studies.

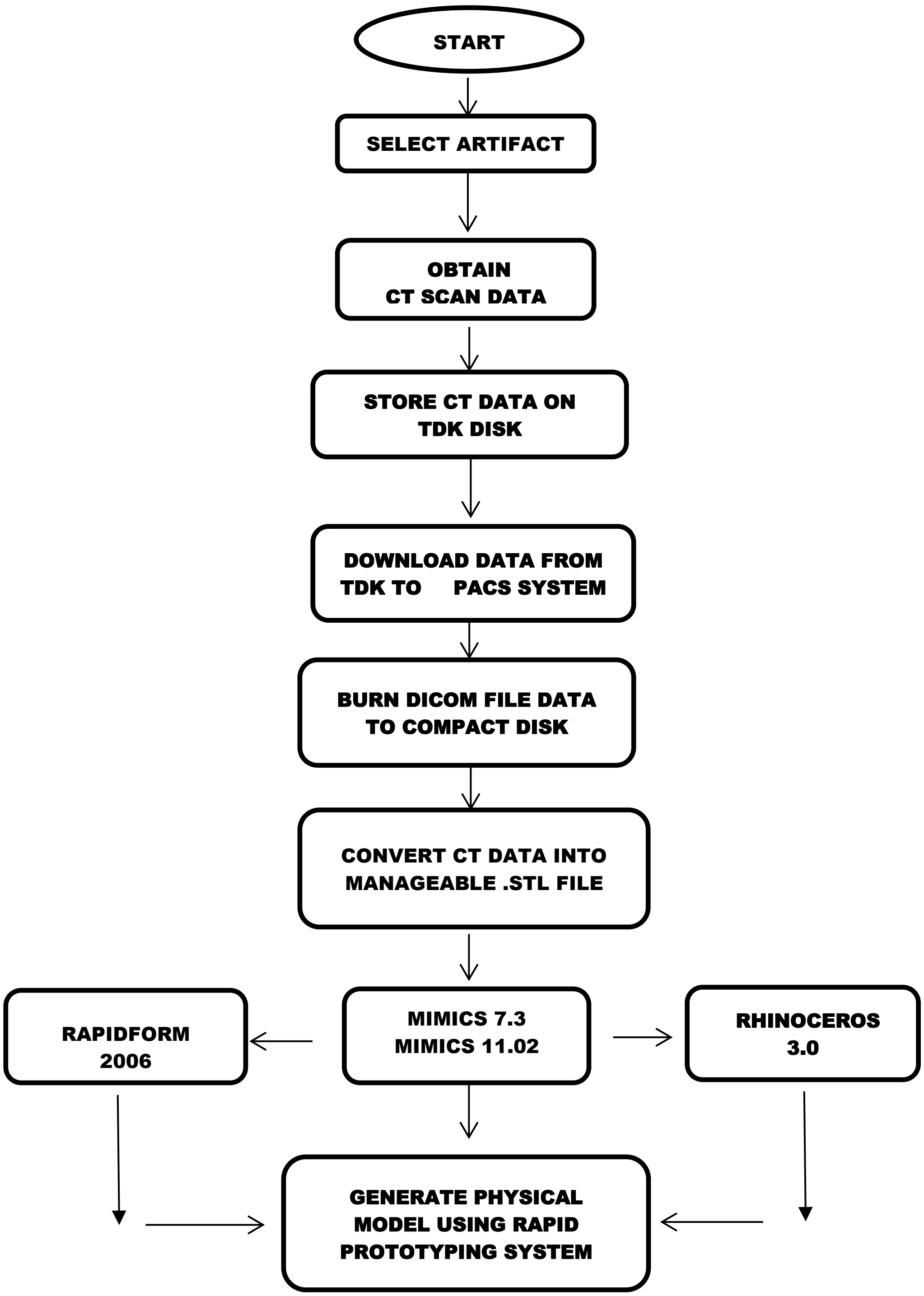

Table 4. Protocol flowchart for constructing an artifact model from CT acquired data sets and rapid prototyping technology.

Degree of encrustation	Artifact must be completely encased in encrustation
Physical condition of artifact	Artifact must be stabilized and able to withstand limited physical stress resulting from the CT scanning process
Physical make-up of artifact	Artifact must be complex; made of both organic (leather, wood) and inorganic elements (metals and various alloys).
High Degree of artifact complexity required	A complete sword hilt consisting of several individual components and a simple wooden sword grip will serve as test subjects.
Significance of artifact (Nature of the data required)	An exceptional specimen, the sword hilt was the only one of its type recovered from *Belle*.

Table 5. Artifact selection criteria developed for the use of *La Belle* artifacts during the CT scanning and rapid-prototyping processes.

Image Reconstruction Using Computed Axial Tomography

Computed Axial Tomography

There are many tools at the conservator's disposal. Two of the most important of these is the conventional x-ray and computed axial tomography. Archaeologists have been using x-ray technology almost as long as those involved in the medical field, and like medical professionals, conservators are constantly seeking new ways to increase the amount and accuracy of the information provided them by different radiographic and digital techniques (Meyers 1978:79-96;

Lang and Watkinson 1992:38-41; Lang 1997). The images from these new techniques, also provide the conservator with the information needed to devise an appropriate conservation plan. An indispensable diagnostic tool, x-ray is utilized throughout the conservation process in order to maintain the process and as a necessary precaution as the artifact undergoes conservation treatment. X-ray and other radiographic modalities are also used to monitor the post-conservation life of the artifact (Cronyn 1990:60-63; Shearman and Dove 1997:136-140; Hamilton 1996:53; Bradley 2010:82-96).

Computed axial tomography, or CT for short, is a non-invasive, non-destructive means of examining archaeological artifacts and has been utilized extensively in the conservation process (Reimers and Riederer 1984:77-79; Anderson 1995:609-617; Casali 2006:24-28; Artioli 2010:71-74). A CT scan produces two-dimensional images or slices that reveal the interior of an object as if it had been sliced open along the image plane for viewing. To produce computed tomographic images, x-rays pass through the object along several different paths in several different directions, resulting in an image that displays differences in density at each of several thousand points in a thin two-dimensional slice through the object.

Each slice represents a finite thickness, determined by imaging conditions, so by layering a series of contiguous equidistant slices, it is possible to construct a continuous three-dimensional map of the density variations in an object. While this technique was originally developed for the medical industry, a similar technique has found industrial and construction applications. Industrial CT units are capable of significantly higher X-ray intensity and much higher spatial resolution then their medical counter-parts (Quinn and Sigil 1980; Halmshaw 1995).

In the simplest approach, a set of CT images can be produced by directing a fanbeam of horizontal X-rays at an object on a turntable, measuring the intensities of X-rays through the fan beam before it enters the object and after it passes through, then rotating the turntable slightly and repeating the measurements. A slice is complete after collecting the intensity measurements for a full rotation of the turntable. The turntable is then shifted vertically by a fixed amount and the entire procedure is repeated again to generate additional slices of the object. As the proceeding conservation case studies reveal, one of the main benefits of CT generated data is that this data can be used to paint three dimensional images that can be viewed from any perspective on a computer, and generate models of artifacts by using three dimensional imaging software, and current rapid-prototyping technology.

Conservation Case Study #1: Methodology and Testing

Some of *La Belle's* artifacts were actually found outside the hull of the ship. These were quickly covered by ocean sediments, affording them comparable protection to those artifacts remaining within the wooden hull remains. One such artifact (Artifact No. 12930), 2019N/2007E, was a sword hilt completely covered by a thick layer of encrustation (Figure 41). This encrustation consists of a hard, sandy-shell matrix that can range in degrees of thickness, partially or completely covering the artifact. The encrustation protected the hilt to a degree, but did not completely halt the decay and corrosion of the hilt components.

Initial X-ray analysis revealed that the metal components of this hilt assembly were constructed using two types of metal, brass for the hilt and iron for the blade. The organic elements of the hilt, such as the sword grip, which was made of wood, and quite likely covered or wrapped with a thin piece of leather, were all in various states of deterioration. The entire grip assembly is held together by a metal wire braiding; with the remains of the iron or steel tang of the blade running through the length of the grip.

Figure 41. Heavily encrusted sword hilt (Artifact No. 12930). Despite the encrustation, the distinct shape of a sword hilt can be made out. *Photo by J. Kampfl*

The condition of the hilt made any type of conservation effort risky. Simply removing the encrustation from the surviving hilt remains could result in the damage or destruction of the fragile hilt components. The ability to record the radiological and CT data to replicate the artifact without actually penetrating or removing the encrustation would reduce the risk to the artifact remains and still provide the archaeologist with important diagnostic information before any attempt is made to remove the encrustation and conserve the sword hilt and it's components The next step involved subjecting the object to a series of CT scans in order to acquire the necessary data to create a 3D model of the artifact prior to removing the encrustation.

A series of CT scout films were taken of the encrusted sword hilt using a GE HiSpeed CT/I machine, owned and operated by The Physician's Centre of Bryan, Texas. The artifact was first scanned in 1mm slices utilizing a high energy technique to penetrate the encrustation and metal of the sword hilt. The parameters of the sword hilt scan were set at 120kV and 100mA, using a 512x296 pixel BONE algorithm. CT machines utilize electronic x-ray detectors that measure the intensity of the x-ray attenuation. The algorithm is a mathematical or attenuation coefficient based on these measurements, which allows the technician to compensate for energy scatter and absorption as the beam passes through the scan subject; resulting in a substantially more accurate, detailed rendering of the desired image. Contrast in a CT scan image is generated by differences in x-ray absorption that arise principally from differences in density of the component parts of the object.

The images produced by this initial scan by far surpassed those taken by conventional x-ray, both in detail and image quality (Figure 42). I decided to run the encrusted hilt through a full series of CT scans. The CT machine used was the same as that used for the scout films. This series of scans consisted of 1mm slices utilizing a high energy technique; the parameters of the scan were set higher than the scout films at 140kV and 260mA, using a 512x512 pixel BONE algorithm.

All of the data accumulated from the CT scans were downloaded and stored on a TDK

Rewritable Magnetic Optical Disk. The next phase required the CT data be stored on a medium that was compatible with the PC desktop systems being used at the Texas A&M University

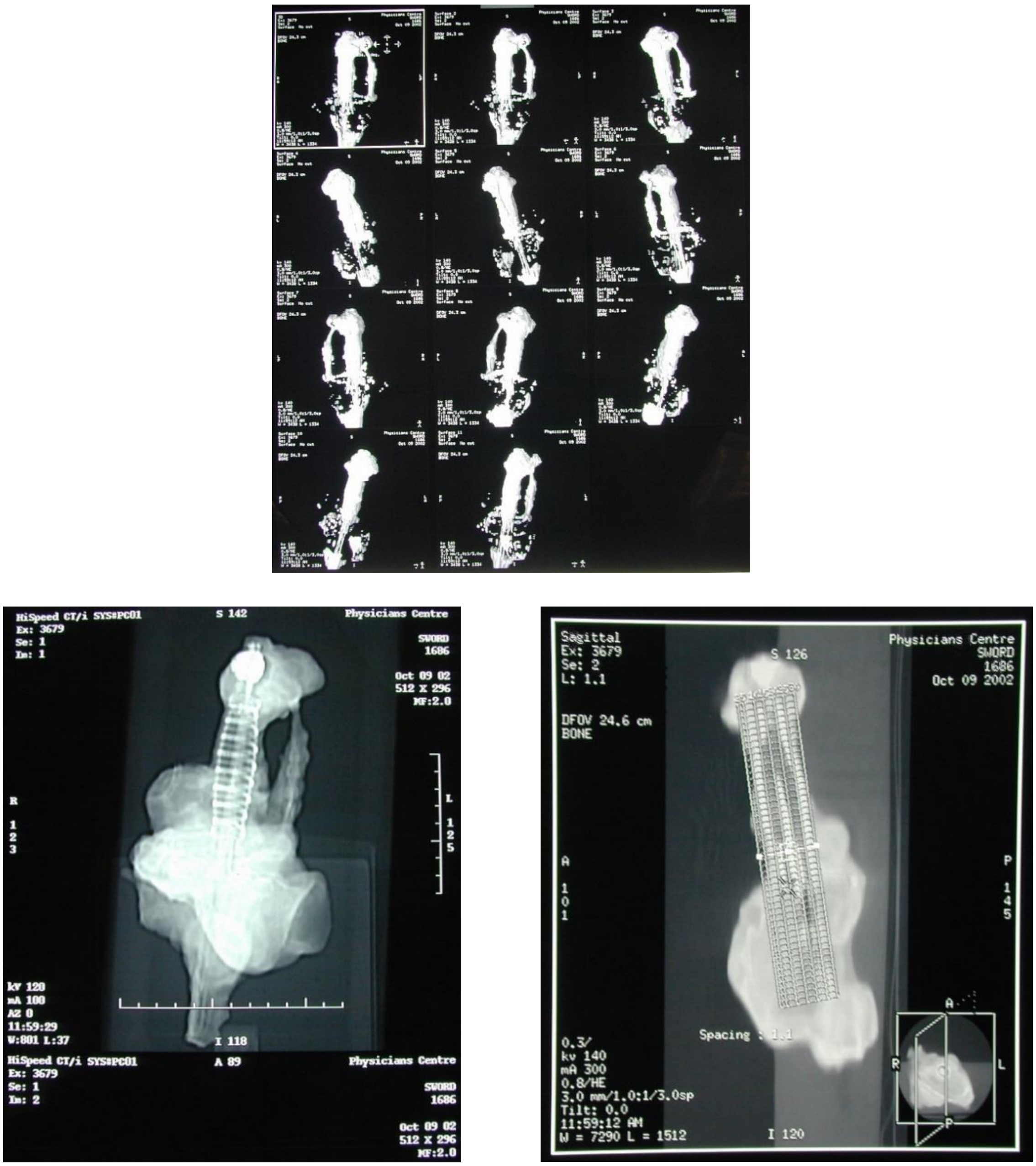

Figure 42. Initial CT scan series (SWORD.1686) of encrusted sword hilt (Artifact No. 12930). Note the definition of detail and clarity of the digitally produced CT images. *Photo by J. Kampfl.*

Conservation Research Laboratory. The information on the magnetic optical disk was downloaded into a PACS system. The data, reformatted and compressed into a DICOM file, was then burned onto a CD. The Picture Archiving and Communications System or PACS, is an application or integrated system that uses an image server to exchange X-rays, CT scans and other medical images over a network.

The system is also capable of storing, retrieving, and managing large files of digital images. In 1982, the American College of Radiology and the National Electrical Manufacturers Association combined to develop a standard for Digital Imaging and Communications in Medicine or DICOM. DICOM is an international communications standard that defines the format used to transfer medical image-related data between different pieces of medical equipment and can then be viewed on any personal computer (Huang 2010:217-219, 629-631).

The scanning process produced a large number of films, all of excellent quality. The full series CT scan of the sword hilt consisted of 841 slices. Because of the extensive size of the file and the complexity of the artifact, I decided to limit any further effort to the reproduction of the upper segment of the sword blade only, which consisted of a total of 20 slices. This particular type of iron sword blade, which survived only as an encrustation mold, was the only one of its kind discovered among the wreckage of *La Belle*. Its unique cross-section is hollow in the center with four distinct fluted edges (Figure 43). The ability to reproduce this blade segment using rapid prototyping or other three-dimensional printing technology would spare the encrusted artifact the need to undergo a casting procedure that could potentially damage or destroy the remaining blade fragments (McAllister 1999:11; Grimm 2004:37,125-129,314; Mödlinger 2008:1-3).

Mimics, a specialized CT and MRI visualization and processing software, was used to isolate and render the slices into three-dimensional images (Figure 44). The data was then converted into an STL file format using *Rhinoceros 3.0* software. From the STL file, the Z Printer 310 Rapid Prototyping system was able to reconstruct or 'print' a section of the sword blade. The Wilder Three-Dimensional Imaging Laboratory of the Center for Maritime Archaeology and Conservation in the Nautical Archaeology Program of Texas A&M University originally used a Z Printer 310 Rapid Prototyping System, manufactured by Z Corporation. The Z Printer is a

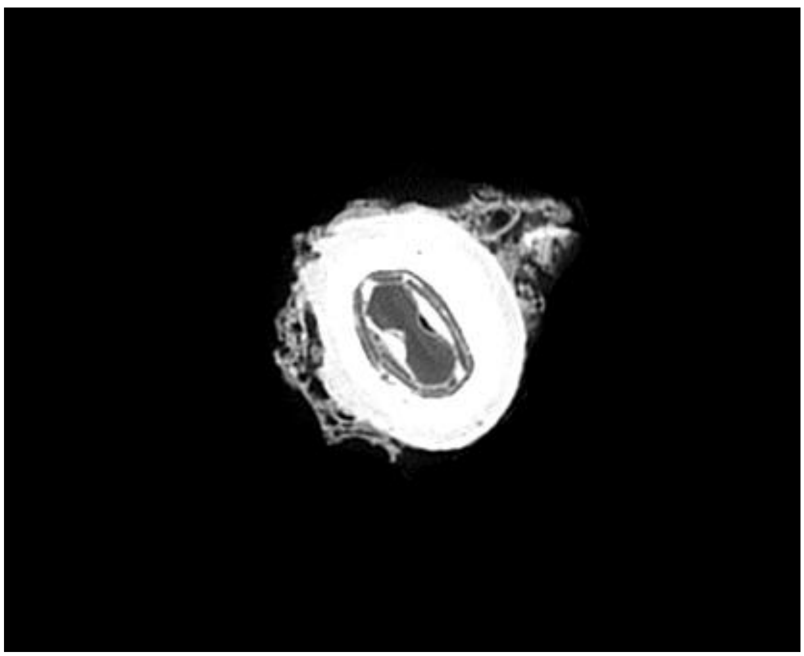

Figure 43. CT scan image of sword blade segment just below the ricasso, the shadow of the wooden scabbard and the surrounding marine encrustation impregnated with iron and brass corrosion products (Artifact No. 12930). The desired specifications of the eventual model can, in-part, be determined by selecting specific slices. Slices 45.27 – 65.27, represent the range of scan slices from the hilt showing only the surviving blade segment. *Photo by J. Kampfl.*

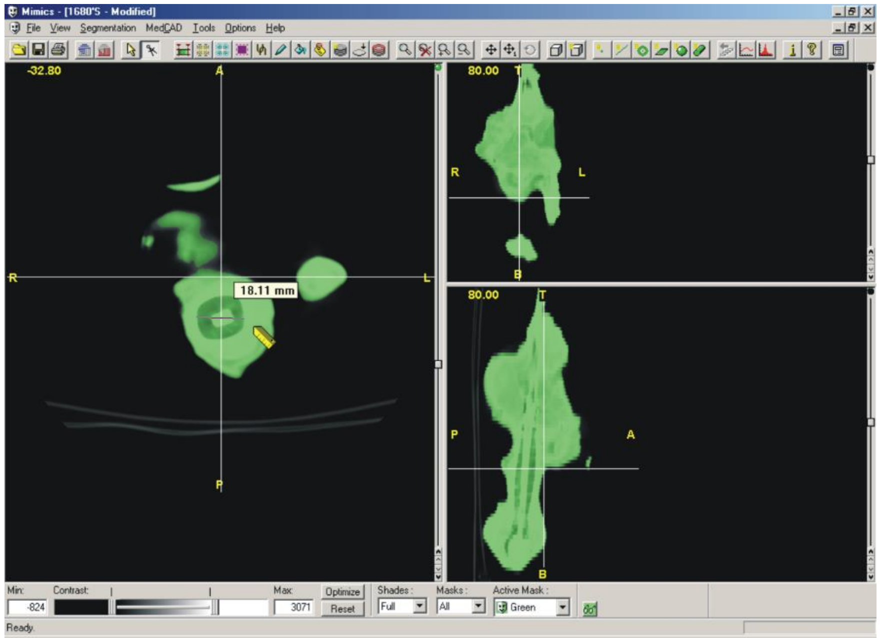

Figure 44. Digital image of sword hilt (Artifact No.12930). The *Mimics* software application possesses a measurement tool which allows the user to take accurate measurements of specific areas of interest. The above image shows the width between the inner walls of the wooden small sword grip. *Photo by J. Kampfl.*

solid model building device, which constructs a part by taking a CAD file, in STL format, and literally builds up the part layer by layer (Chua et al. 2010:213-221).

Three-dimensional models are fabricated by using a variety of synthetic materials; such as wax, resin, and starch or plaster based powders. The blade segment model was constructed on the Z Printer by spreading a layer of a white plastic-ceramic based powder, fabricating or 'printing' the cross-section of the object using a special binding solution. The Z Printer 310 builds one layer after the other to produce a three dimensional replica of the sword blade segment (Figure 45). Following its extraction from the machine, the model was coated with a curing or bonding agent consisting of a liquid alcohol-based, polyvinyl alcohol in H_2O and ethanol synthetic polymer. The model was allowed to sit as the curing agent required time to dry and sufficiently harden before handling (Venuvinod and Weiyin 2004:48-51, 299). The finished product, which is white with a slightly granulated surface texture, has the look and feel of limestone.

The blade segment replica consisted of 238 printed layers, measuring 23.4mm in length, 20.2 mm wide, with the cross section measuring approximately 19mm. It took approximately 30 minutes to fabricate the complete model. The model retained its hollow cross section shape, though the edges of the blade were somewhat rounded. The details and shape of the model are exceptional, however since the dimensions of the original object are not known, and the corrosion process could have altered the overall size of the blade, it is not possible to compare or contrast the measurements of the 3D printed model to the original blade.

a  *b* 

Figure 45. Three-dimensional model of sword blade section (Artifact No.12930). Certain diagnostic details of the blade segment were visible; *(a)* Flat of the blade showing fuller. *(b)* Cross-section of the blade showing double fuller and blade edges. The model was fabricated using the Z Corporation Z Printer 310 System. *Photos by J. Kampfl.*

The software used to process the CT generated images was Materialise Corporation's Interactive Medical Image Control System or *MIMICS*. *Mimics 7.3* is an interactive software tool that reads CT or MRI data as two-dimensional uncompressed images. The software interface utilizes several different segmentation, editing, and visualization tools. These tools make it possible to differentiate between bone-matter and soft tissue and thus, metal and wood. This specialized software also has the ability to produce three-dimensional visualizations of objects, possessing a very flexible interface to rapid prototyping systems.

Mimics software enables the operator to define and process images using various windowing and segmentation applications, displaying the image data in several different ways; dividing the screen into three views: the original axial view of the image, and resliced data making up the coronal and sagittal views, each view providing unique information. *Mimics* software includes several visualization functions such as contrast enhancement, panning, zooming, and rotating of calculated three dimensional images. Three dimensional rendering and information tools provide an easy to use interface calculating a three-dimensional model of the region of interest. This allows the user to set parameters for resolution and filtering. Information about height, width, volume, and surface is available for every three-dimensional model. *Mimics* can display the three-dimensional model in any of the windows with visualization functions that include real-time rotation, pan, zoom, and transparency.

Two unique reslicing tools are available: the online reslice tool and the export resliced project tool. On-line reslicing allows you to display cross-sectional and parallel images that are orthogonal and along a user-drawn curve in the axial view. Users can define several different reslice curves that are saved in a project file. The export resliced project tool has an easy to use interface that allows you to export a resliced project along a user-drawn line. This line can be drawn in any perspective or orientation.

The *Mimics* software also incorporates numerous measurement taking tools into its software program: point to point measurements can be performed on both two-dimensional slices and three dimensional reconstructions. A profile line displays an intensity profile of the grey values along a user-defined line. The user can make measurements based on the grey values using three methods: the threshold method, the four-point method, and the four-interval method. Density measurements can also be taken in an ellipse or rectangle area: area, mean, grey value and standard deviation are displayed. All measurements are saved in the project file and are listed in the project management.

The enhanced print function allows the user to print a complete report with general project information, three-dimensional views, and all axial and resliced images. Screenshots can be saved from all views and printed or filed as BMP or JPEG files. Images can also be exported in BMP or JPEG format in 1:1 scale. The Project Management dialog provides an ideal way to organize and interact with the data: segmentation masks, three-dimensional renderings, polylines, STL files, measurements, and profile lines and their properties.

The production of the sword blade segment demonstrates it is possible to fabricate a model of a specific part or component of an artifact by selecting a range of CT scan slices and printing from this data. The materials used to construct these replicas are extremely durable, allowing for their continued examination and handling by weapons researchers. One of the major obstacles encountered was the configuration and complexity of the sword hilt, and its many components, made replicating the entire hilt as one solid piece extremely difficult. The fabrication material, or powder, mixed with a binding solution requires sufficient time to dry and harden, during which some shrinkage of the fabricated model might occur.

Any attempt to construct the hilt in one piece, would most likely result in the intricate components caving in on themselves. It should be possible to construct each hilt component as a separate element, and attach them using the binding solution by hand at a later date. Materialise is also developing a newer version of *Mimics*, which would include the ability to manually add support structures to an object during the 3D printing stage. These supports would allow for the fabrication of complex, intricate models. Great care has to be taken during the physical removal of these support structures as the process might irreparably damage the model.

Conservation Case Study #2: Methodology and Testing

The subject of the second experiment was a slightly encrusted small sword grip (Artifact No. 7296-12.1) (Figure 46). The remains of an iron tang were encased by the wooden grip and the near complete encrustation mold of a heavily oxidized iron pommel was still attached to the top portion of the grip. Iron wire braiding had at one time bound the grip, but initial x-rays revealed that the wire had corroded away leaving only deep impressions on the surface of the wood. The parameters of the sword grip scan were set at 120kV and 40mA, using a 512x296 pixel BONE algorithm (Figure 47). The completed CT scan of the grip consisted of 126 slices.

As with the first case study, the CT data was converted in an STL file using *Rhinoceros 3.0*. The digital image was then processed using the *Mimics 7.3* software package. The fairly minute amount of encrustation surrounding the grip was eliminated without difficulty using the *Mimics* editing tools. This procedure effectively simulates the process of removing the encrustation allowing for a much improved inspection of the artifact; and aids in developing a conservation plan for the sword grip.

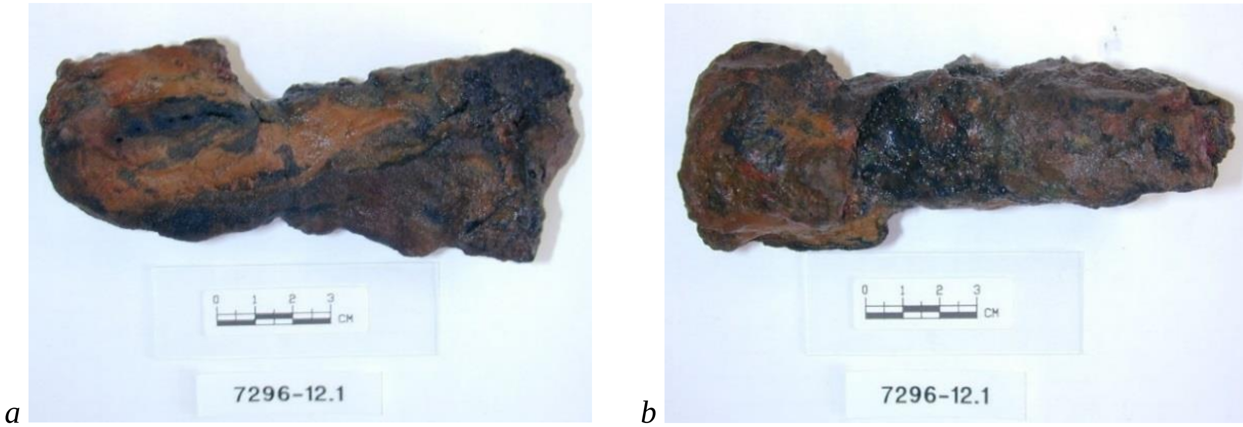

Figure 46. An encrusted small sword grip and pommel (Artifact No. 7296-12.1).
(a) Front view of grip and slightly exposed iron pommel. *(b)* Rear view of grip. Elements of corroded iron grip-wire are visible near the center of the grip. *Photo by J. Kampfl.*

Figure 47. CT scan digital image of small sword hilt (Artifact No. 7296.12.1). *Photo by J. Kampfl.*

This information was then sent to the Z Printer 310 to produce the final model fabrication. The resulting model consisted of 238 layers, taking a total of 33 minutes to complete (Figure 48). Though there was a slight reduction in the overall dimensions of the replica, the essential shape and details, such as the wire braiding impressions left on the wooden grip, were all accurately reproduced on the model. In an attempt to create an even more accurate replica of the original artifact, a second model was fabricated then painted by hand to match the colors and detail of the original wooden grip (Figure 49).

Figure 48. Small sword grip and pommel (Artifact No.7296-12.1). The first model immediately following its extraction from the ZPrinter 310. The impressions left by the ferrules and grip wire are visible. *Photo by J. Kampfl.*

Figure 49. The artifact on top is the original wooden grip with most of the encrustation and corroded pommel removed. The bottom object is a model of the grip artistically rendered to resemble the original artifact. *Photo by J. Kampfl.*

In an attempt to compare and contrast different 3D modelling software packages, *Rapidform* 2006, developed by INUS Technology, was also used in this case study. *Rapidform*, like *Mimics*, can convert the CT data into a format compatible with the Z Corp printer. *Rapidform* is a 3D freeform modelling software, which can process the CT/DICOM files using CT data like slice thickness information, converting it into a polygonal surface. Following the startup of *Rapidform*, the user must select and open the 3D Imaging workbench. Going to the File tab and selecting Open DICOM will cause the Import DICOM screen to appear (Figure 50). *Rapidform* will then display a list with all of the imported files. The user can select or highly the file requiring processing.

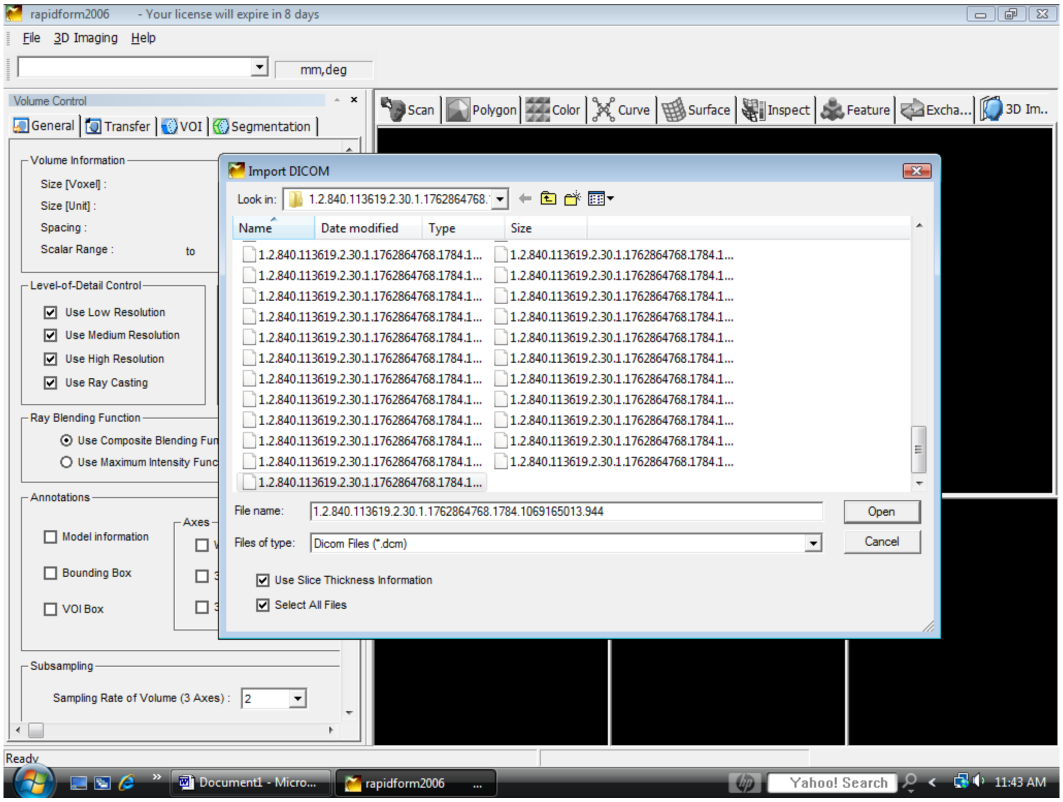

Figure 50. The imported DICOM files as they appear in *Rapidform*. All of the DICOM files will have the .dcm file extension.

Selecting the Use Slice Thickness Information box allows the main screen to display the CT data as color based files, the darker center showing the actual data information. The bottom three screens represent the XY, YZ, and XZ views of the same object. The item on the main screen can be manipulated using the mouse arrow (Figure 51). The VOI tab allows the user to select the minimum and maximum value of each coordinate axis using six slide controls. This allows the user to view the object in sections or slices, manipulating the main screen or the X, Y, and/or Z axis views (Figure 52).

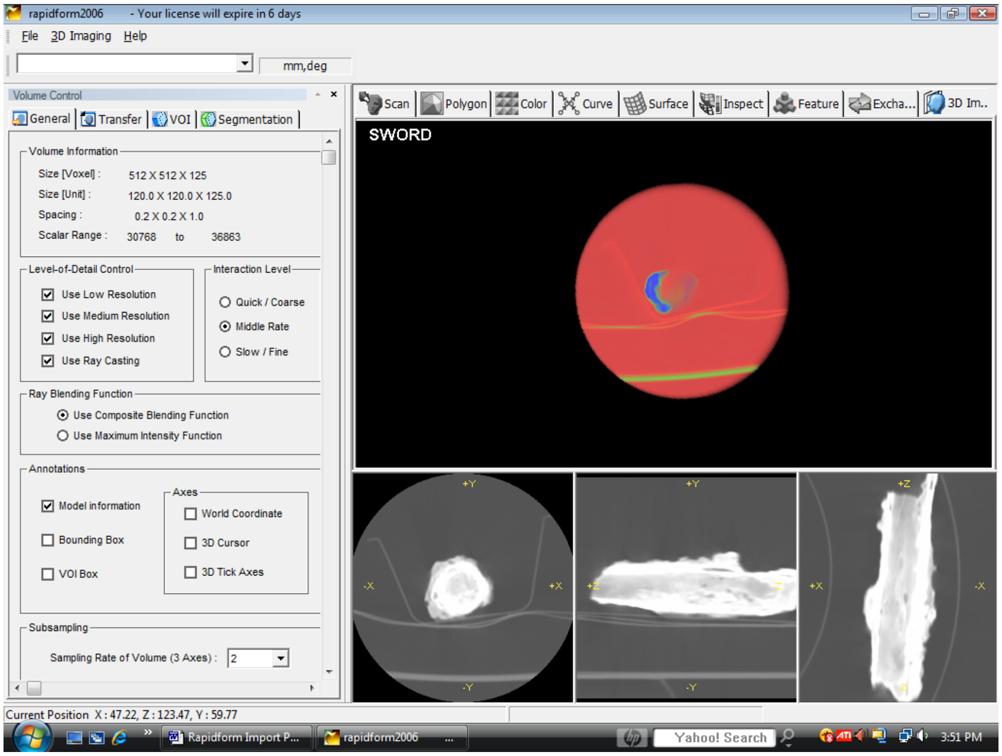

Figure 51. CT data of sword grip displayed on *Rapidform* as color based files.

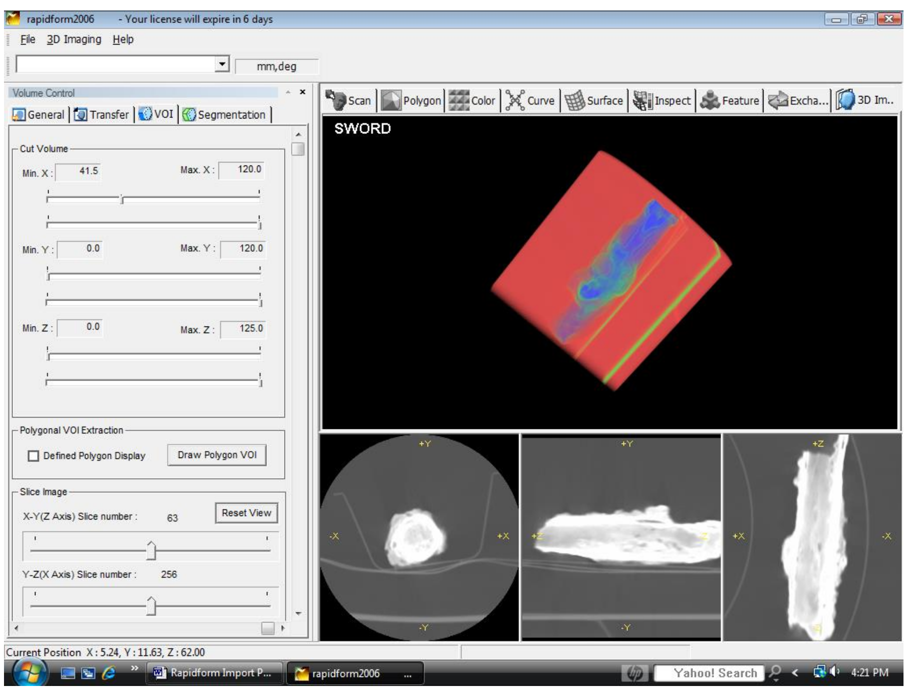

Figure 52. *Rapidform* VOI tab. At this point the information is in the form of raw CT data, not yet processed into any polygonal data.

The CT data can now be converted into a polygonal surface. While in the 3D Imaging workbench, select the 3D Imaging tab. Select Generate Polygonal Isosurface. Before the image can be processed further, it must be turned into what *Rapidform* calls a SHELL. Select the 3D Imaging tab. Select the Make Shell option. Doing so allows the user to eliminate the slicing affect, and develop the image into one solid body. *Rapidform* will then transfer the user to the Polygon Workbench as seen below (Figure 53). The image is now seen as an object that has been knitted together as one solid shell. Polygon Workbench gives us a number of tools to manipulate the model/subject. The Curve Workbench allows the user to create slices or cross-sections of the object. A slice can be created on any axis – manipulating the cross-sectional curves of the CT data (Figure 54), while the Scan Workbench allows the user to create and work with multiple shells (Figure 55).

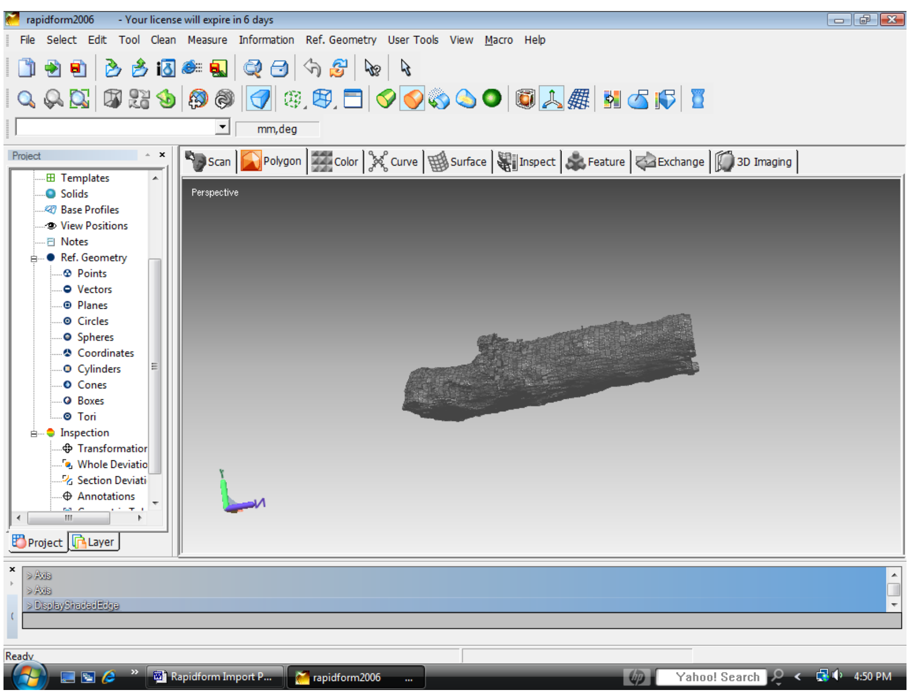

Figure 53. The sword grip now viewed as a solid object or ‘shell.’

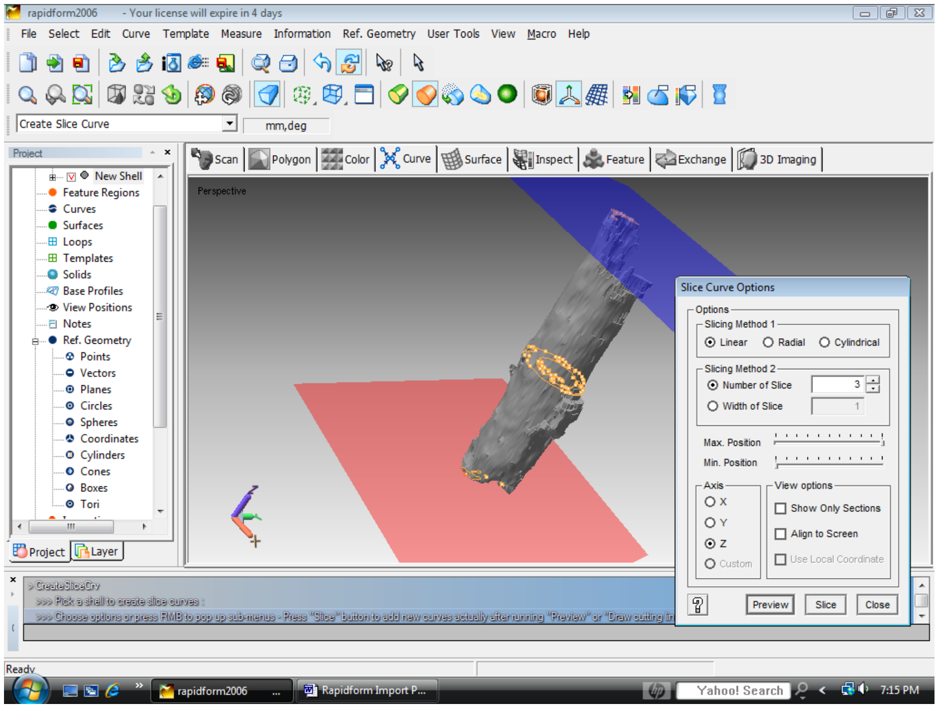

Figure 54. The Curve Workbench showing cross sections of the sword grip.

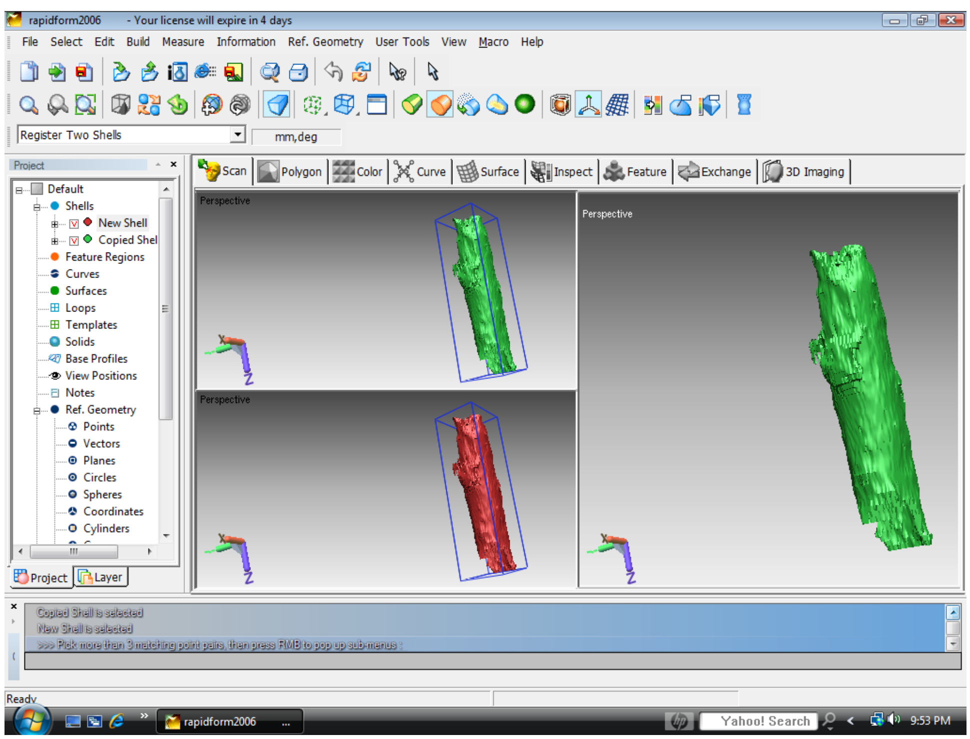

Figure 55. Each image or ‘shell’ of the artifact can be manipulated separately by the user.

A digital image is composed of small surface elements called pixels. Each pixel contains a scalar value or set of values which determines the intensity of each image. A gray scale image is a digital image in which each pixel contains only one scalar value, which designates its overall intensity. A color image is a digital array of pixels containing color information. Each image can be decomposed into different layers according to various color channels: red, green, blue, yellow.

The 3D Imaging Workbench can be used to perform the Segmentation operation (Figure 56). Segmentation is an operation which allows the partitioning of a gray scale or color digital image into sets of pixelated elements by adjusting the threshold level of each image. Adjusting the segmentation and threshold levels of an image allows the user to determine the overall condition of the artifact, as well as differentiate between the different materials used in the artifacts construction (Figure 57). To extract the wood from the image, the user needs to segment the image with a high/low threshold or pixel intensity value. The wood is represented by the bright white areas as opposed to the darker center of the sword grip, which contains the corroded remains of the iron tang.

Finally, the VOI tab allows the user to manipulate the image by removing or cutting away unwanted material, i.e., the concretion surrounding the sword grip (Figure 58). Following this operation, the shape of the actual grip is revealed, however this operation was unable to reveal missing elements of sword grip: wire impressions, pommel and blade shape (Figure 59).

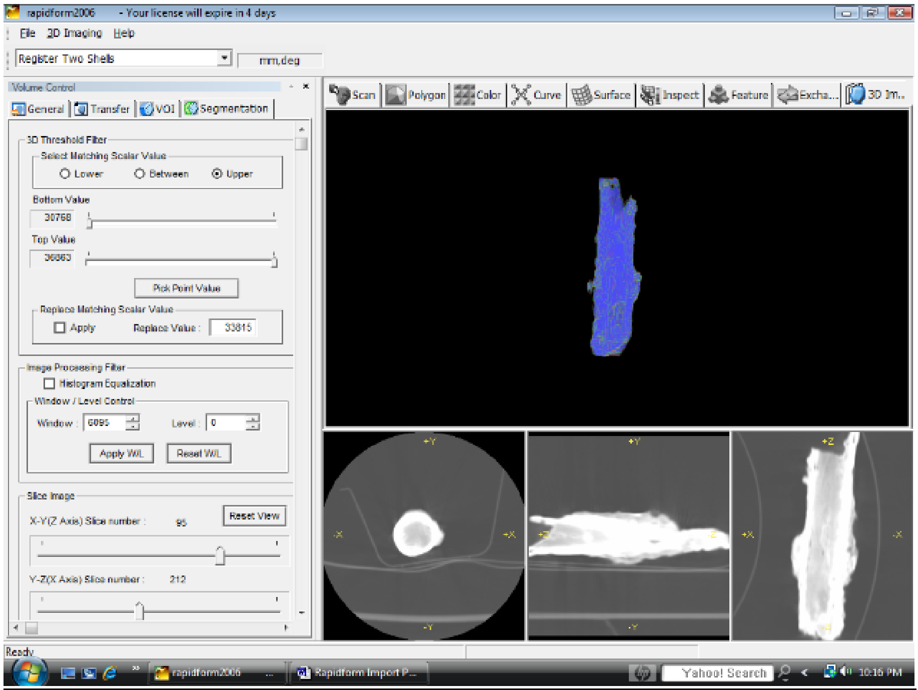

Figure 56. Image of the sword grip undergoes the segmentation process in *Rapidform*.

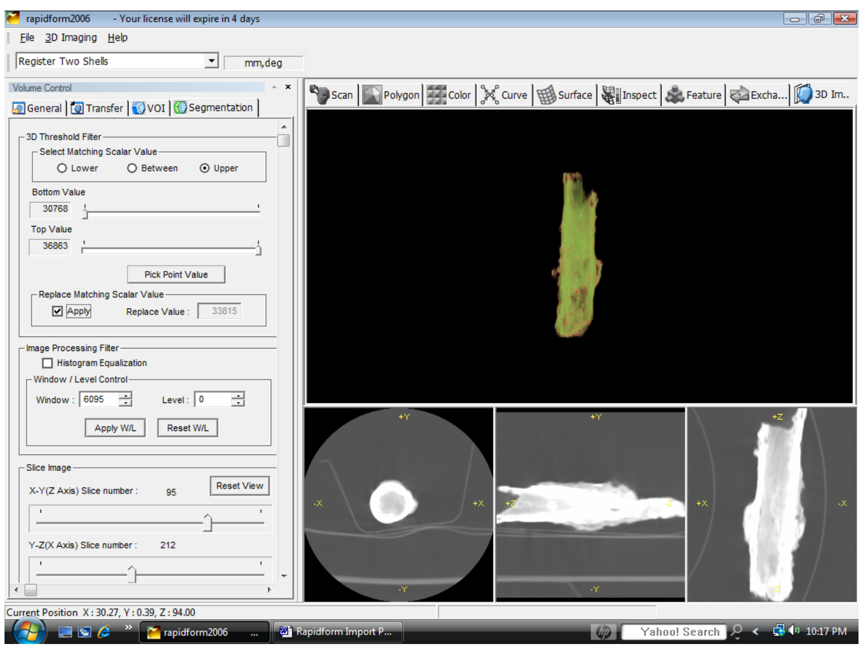

Figure 57. The most widely used method for segmentation is thresholding, which helps to differentiate between the various materials comprising the sword grip.

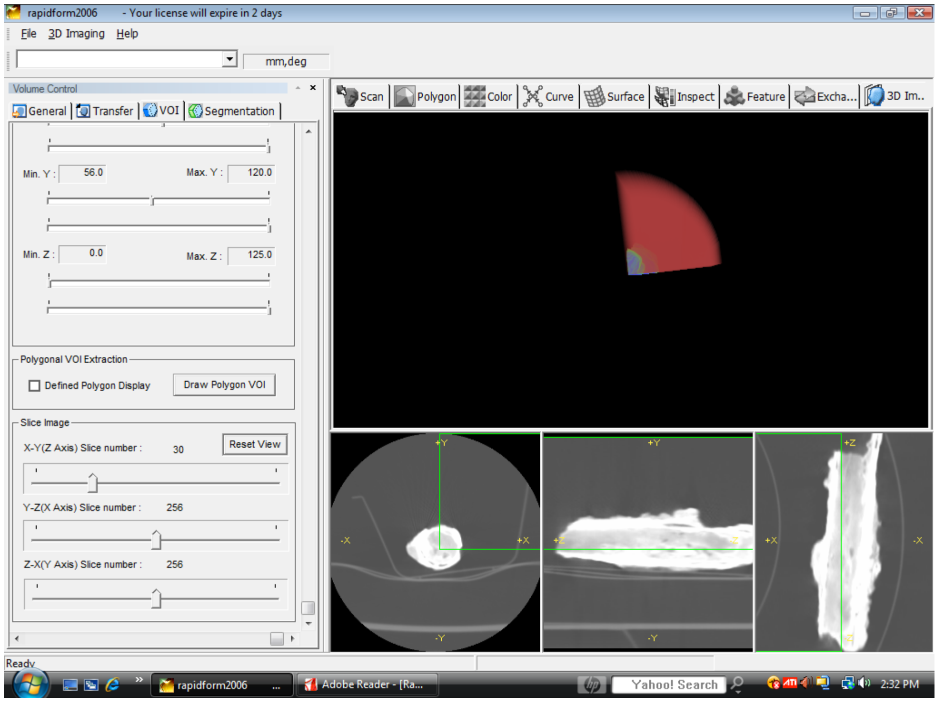

Figure 58. VOI tab indicating the X, Y, and Z slicing.

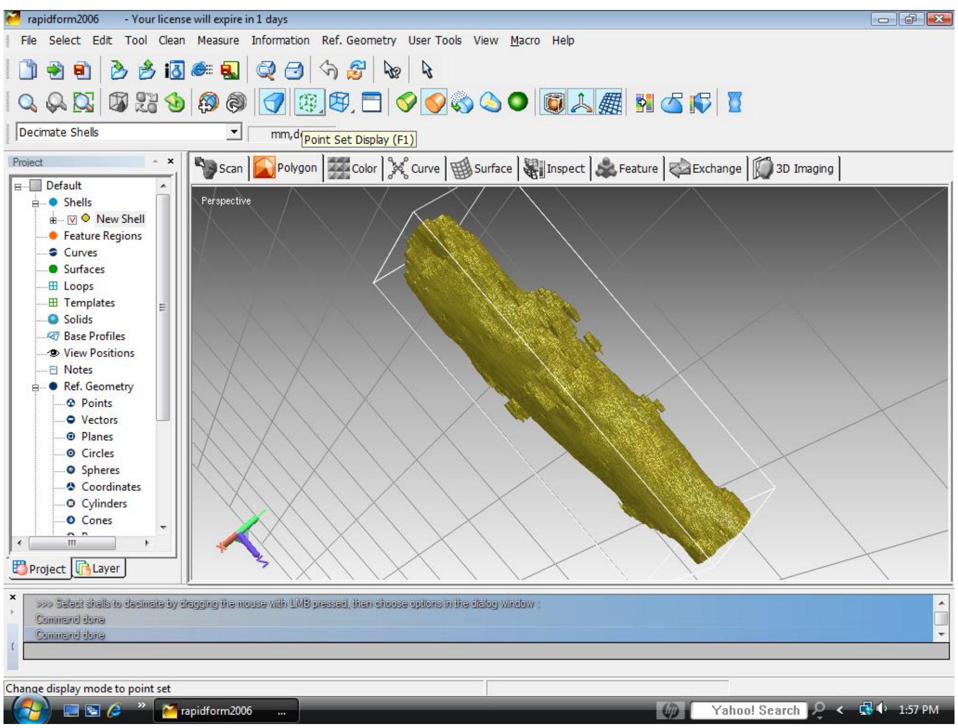

Figure 59. Following the removal of the concretion, the shape of the wooden grip is clearly visible, especially in the lower right portion of the grip.

Following the fabrication of the model, the original wooden grip was conserved at the Texas A&M University Conservation Research Laboratory using a silicone oil treatment. The pommel and tang remains were removed from the grip, properly documented, and then cast using an epoxy resin. The pommel and tang did not survive the casting process.

Conservation Case Study #3: Methodology and Testing

A second set of CT scans was taken of the same encrusted sword hilt (Artifact No. 12930) used in the first case study. St. Joseph's Hospital of Bryan, Texas, allowed us to scan our artifact using a Light Speed QX/I CT Scanner. This series of scans consisted of 841, 1mm slices utilizing a high energy technique; the parameters of the scan were set at 140kV and 260mA, using a 512x512 pixel BONE algorithm (Figure 60).

The CT data were imported into the 3D imaging software *Mimics 11.02,* a newer version of Materialise's 3D design and modelling CT data converter software. My first action was to create a series of segmentation masks by adjusting the threshold levels. Using the Thresholding and 3D Calculate tools allows the conservator to select a region of interest by defining a range of gray values. The boundaries of that range are the lower and upper threshold value. All pixels with a gray value within a specific range are highlighted using a color designated mask (Figure 61).

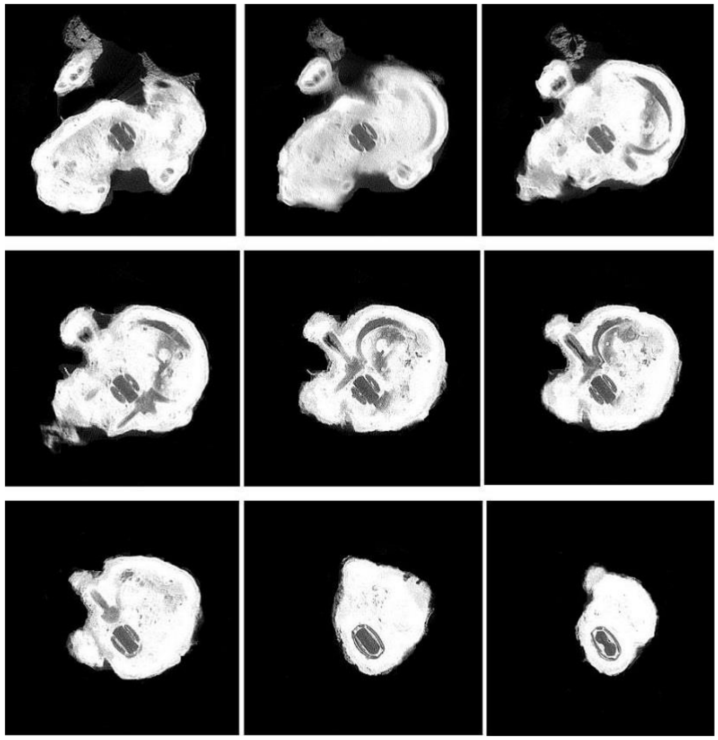

Figure 60. Range of CT scan slices revealing the remains of the sword hilt guard (top two rows), and the upper section of the blade (bottom row).   *Photo by J. Kampfl.*

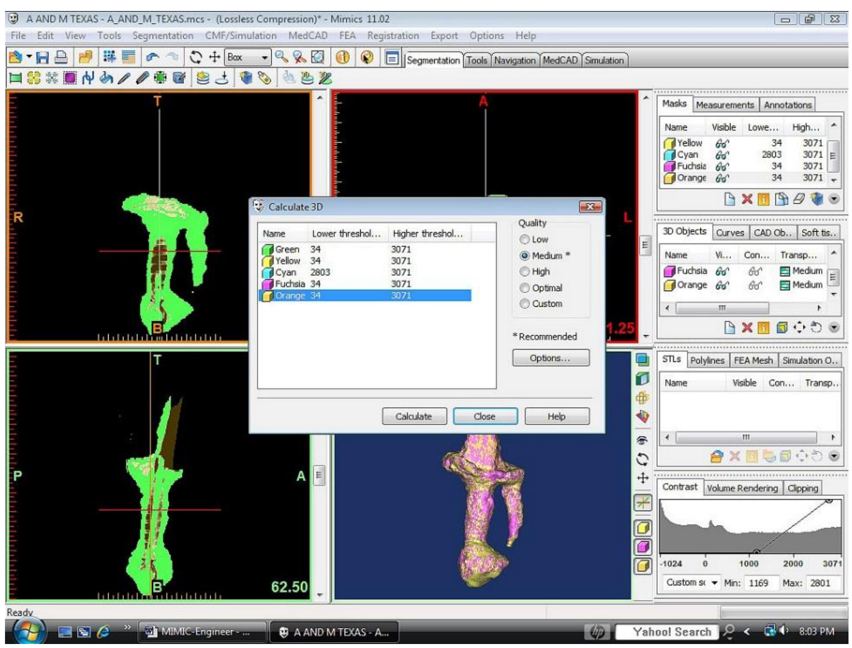

Figure 61. Establishing the threshold values using the Threshold and Calculate 3D tools. *Photo by J. Kampfl.*

Another valuable application found in *Mimics 11.02* is the Pseudo Color tool. Pseudo color works just like the gray values do in a black and white and gray setting. The density of an object in a scan is represented by the darkness level of the gray value, however Pseudo Color assigns various color masks to illustrate the different material densities of the scanned object (Figure 62). The results depend on how much the density varies between the encrustation, the sword hilt, and the material makeup of its various components (Figure 63).

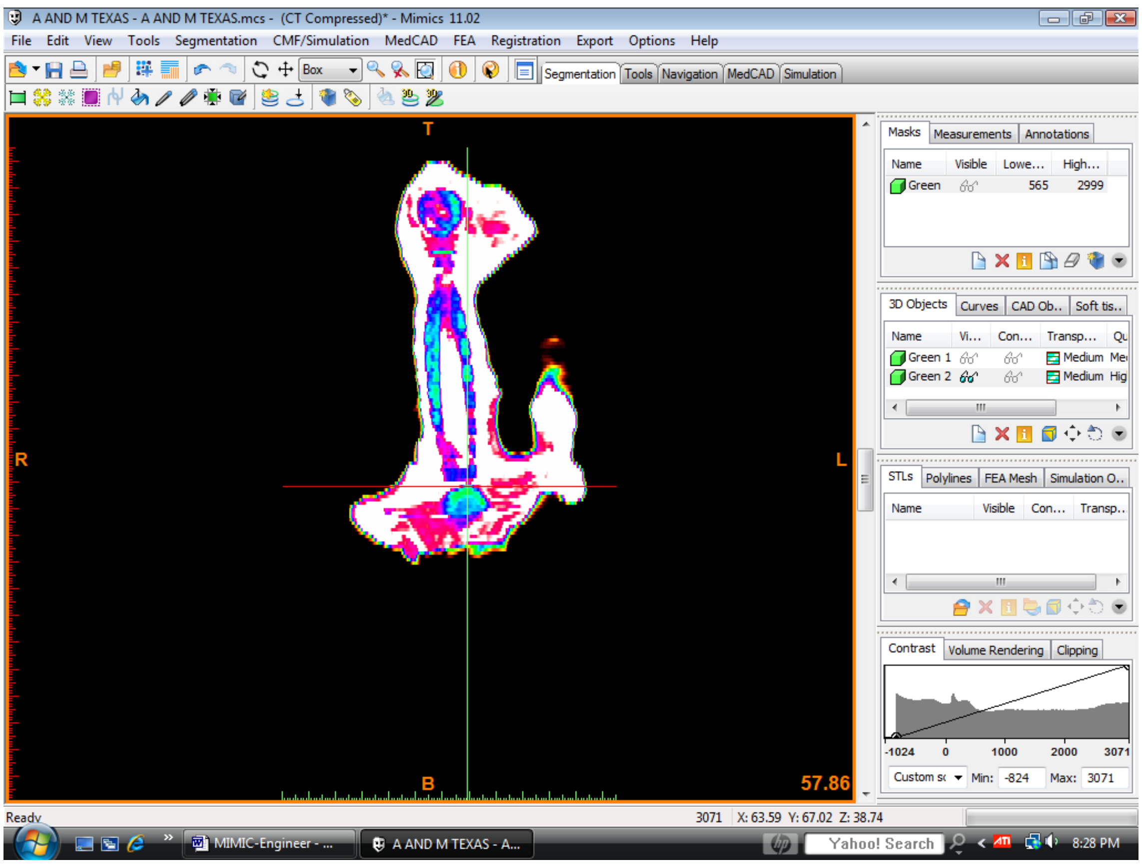

Figure 62. Pseudo Colors – full spectrum. White region indicates existing concretion. Cyan and fuchsia represents the remains of metal components. *Photo by J. Kampfl.*

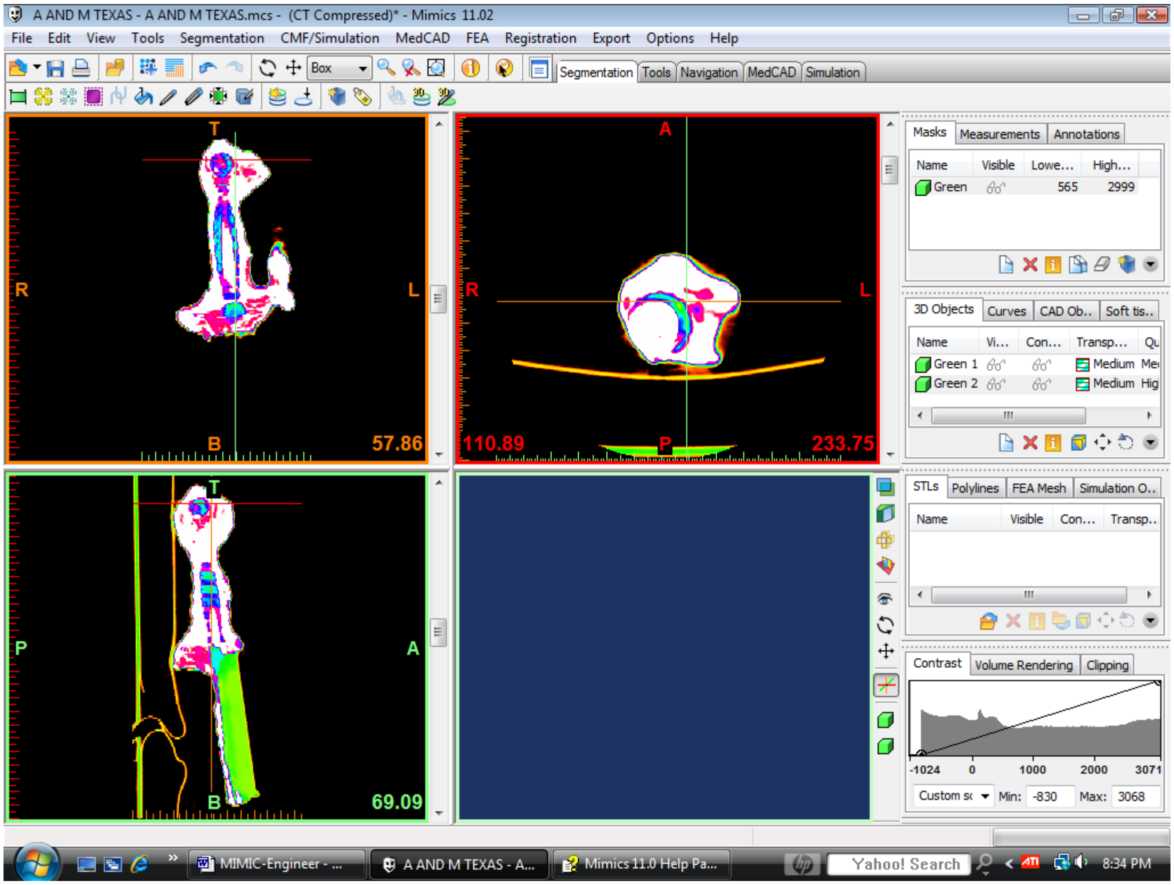

Figure 63. View = Pseudo Colors - Full Spectrum [Notice upper right and left view screen] – cyan colored area signifies nearly exact area of remaining pommel. *Photo by J. Kampfl.*

For this particular project, I also used the morphology function and the manual editing and multiple slice edit tools to segment out the sword from the concretion (Figure 64). The Region Growing tool can then be used to separate structures that are not connected by a given threshold range. This feature allows the user to select a point within a specific component and then expand the region. Various editing tools enables the operator to draw, erase, or restore parts of images within a local threshold value. These tools can be used to remove unwanted objects and scan noise from the image. Highlighting the various material components of the encrustation made it possible to erase the encrustation effectively isolating the remains of the sword hilt (Figures 65-66).

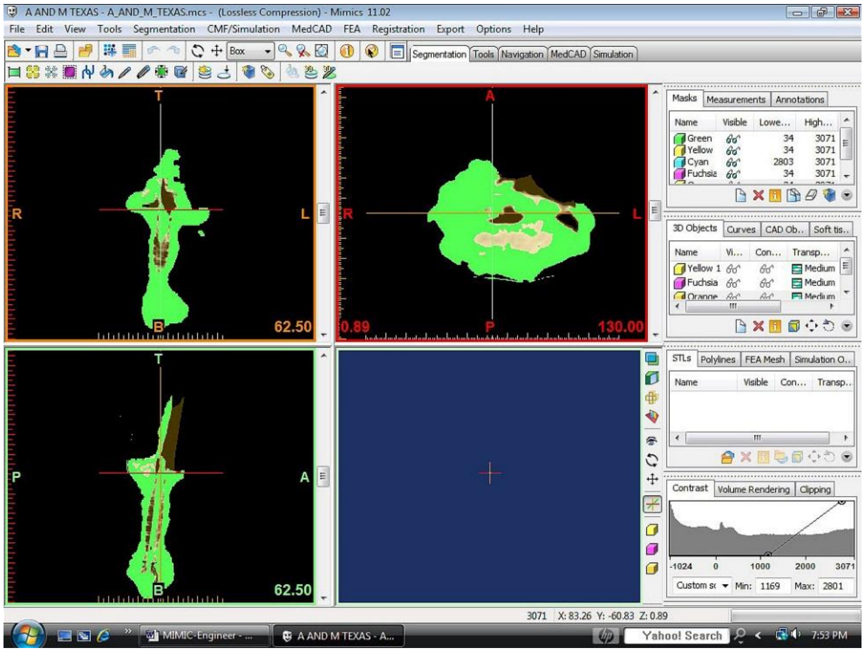

Figure 64. Using the morphology function and manual editing tools allows the user to segment out or isolate the artifact, essentially separating the sword hilt and its components from the surrounding concretion. *Photo by J. Kampfl.*

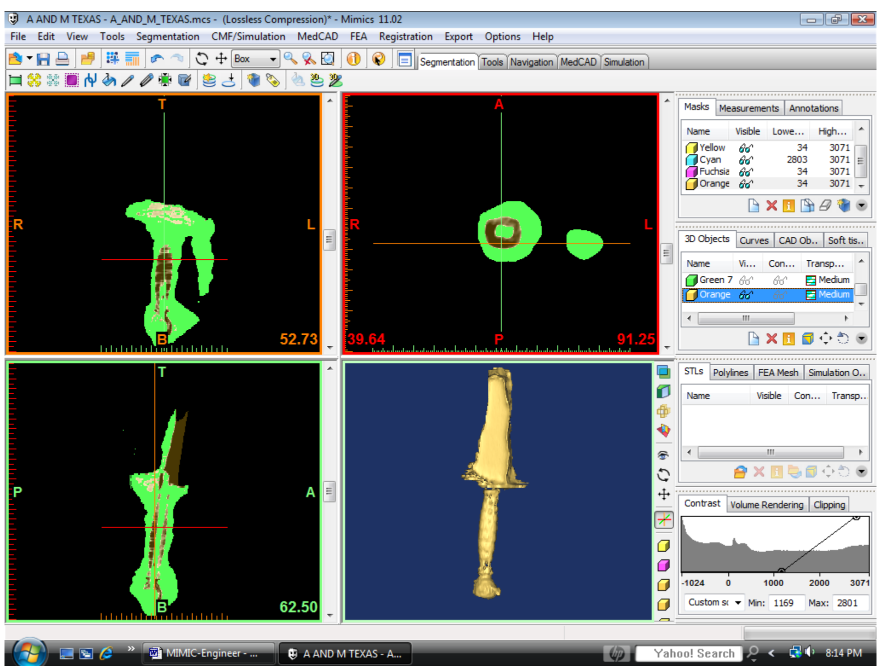

Figure 65. The Region Growing tool can then be used to separate structures that are not connected by a given threshold range. Initial results can be seen in bottom right image screen. *Photo by J. Kampfl.*

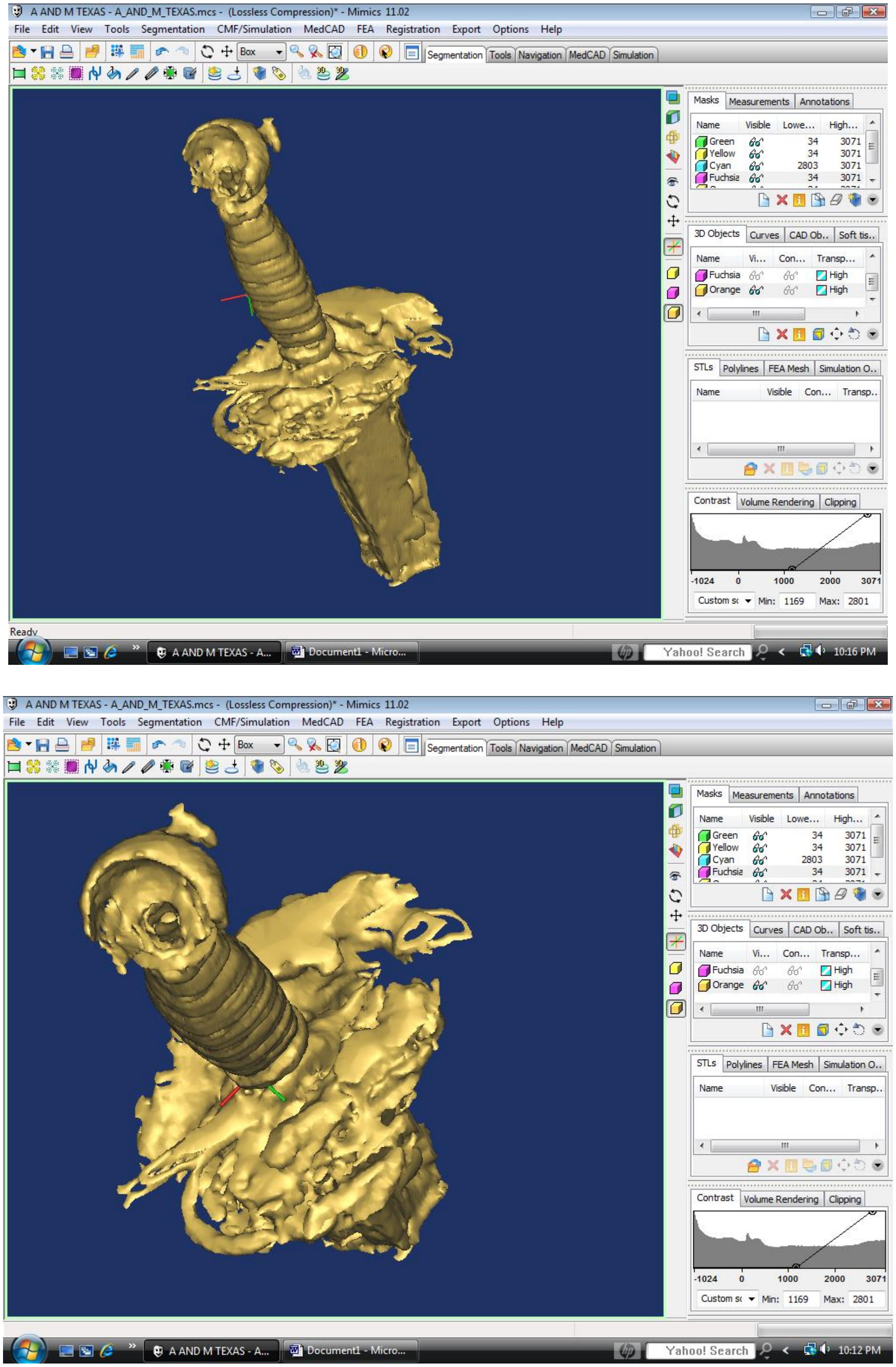

Figure 66. A series of remarkable images of the sword hilt remains following the removal of the surrounding encrustation using *Mimics 11.02. Photos by J. Kampfl.*

Using this new data, another attempt was made to produce a three dimensional replica of the sword remains, hopefully with most of the diagnostic features intact. This time the model was fabricated using a Prusa i3 mk3, open-source fused deposition modeling 3D printer. One of the major differences between the Prusa i3 mk3 printer and the Z Corp. printer is the material used to construct models and parts. Rather than the powder and binding solution used by the Z Corp. machine, the Prusa i3 mk3 printer uses a variety of colored plastic filaments to construct objects. For this particular project a white plastic filament, Hatchbox PLA, 1.75 mm gauge, was used to fabricate the model.

The tremendous detail of this model allows for a more accurate and thorough analysis of the hilt remains (Figure 67). One example of this is the correct identification of the small object protruding from the grip into the pommel. Based on the CT images, I believed this to be a section of the iron tang running through the grip. Upon closer inspection of the model, I was able to correctly identify the object as a small sliver of wood. Sword makers would often wedge small pieces of wood between the tang and the interior of the grip. This would ensure a much tighter, more secure fit preventing the grip from turning on the iron tang while the sword was being used.

The end result of the third case study was a marked improvement from earlier attempts at producing accurate models of the still encrusted sword hilt remains. Despite the many tool and function upgrades that came with the *Mimics 11.02* software, it proved easier to operate than the previous version. The Prusa i3 mk3 3D printer, printing materials, and other peripheral equipment was both affordable and cost effective. The filament used to print the object produced an extremely detailed and durable model. At the risk of sounding obvious, the skill level of the

Figure 67. Using the software application *Mimics 11.02* to process the data acquired from a second set of CT scans, a new model of the still encrusted sword hilt (Artifact 12930) was fabricated using a Prusa i3 mk3 3D printer. *Photo by J. Kampfl.*

operator must be considered. The time which elapsed between the first and third case studies allowed me to become more familiar with radiographic techniques, such as reading the digital images, the *Mimics* software platform, and 3D printing technology in general.

Overall Case Studies Assessments

It was never my intention to produce the definitive study on this topic, nor was it my intention to provide an overarching assessment of the different software programs, 3D printing technologies, etc., currently available on the market. The ultimate purpose of my work was to create a strong foundation from which further research might be conducted on the benefits of current and future technology to artifact conservation. Though the results of the first two case studies were promising, they fell somewhat short of the expectation of producing a complete and accurate model of the encrusted sword hilt. The results of the third case study proved far more encouraging, providing clear evidence of the positive effects on artifact conservation that can be brought about by the use of radiographic imaging techniques, three-dimensional software applications, and 3D printing technology.

The technological applications discussed throughout this chapter have proven to be particularly advantageous when working with fragile objects from a marine- environment in a constant state of decay, covered in layers of encrustation and corrosion products. It is possible to simply cast the mold left in an encrustation by an artifact which has completely corroded away by using a variety of different resins and epoxies, however, any conservation attempt to treat the artifact requires that the encrustation be removed. Silicone molds of the artifact can also be made as the encrustation is carefully removed and then cast. This technique was used during the conservation of the component parts of the firing mechanisms of the muskets excavated from *La Belle*, as described by Dr. Helen Dewolf (Hamilton et al 2017:60-80).

For decades the use of x-ray and other radiographic modalities provided the conservator the nonintrusive means to identify existing diagnostic features, analyze, and assess the material condition of almost any artifact, minimizing the potential damage to the artifact during the documentation and conservation processes. Digital CT data can be stored for an extensive period of time making it possible to reproduce artifact replicas by utilizing rapid prototyping and other three-dimensional printing technology as needed for further research and analysis. Converted CT data can be permanently stored on a CD and referred to in the future as necessity dictates (Figure 68). This data or the finished model can be sent anywhere in the world without putting the original artifact in any danger (Cheng and Mishara 1988:19-38).

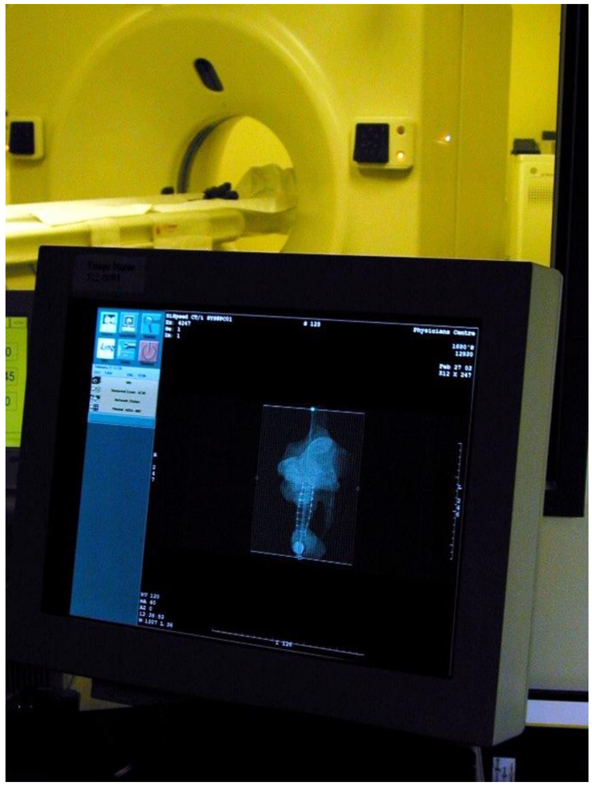

Figure 68. Encrusted small sword hilt (Artifact No. 12930), as it undergoes a series of CT scans. *Photo by J. Kampfl.*

Digital images provided by a CT machine, are in a medium that is more readily edited providing greater details of different areas of an artifact. CT data, as opposed to traditional x-ray film, which must be carefully stored in an environmentally controlled area, can be stored indefinitely in a computer or some type of external data storage device (Figure 69). Another major advantage of using CT data over data produced by a 3D Scanning device, is that the CT scan can capture the internal structure of an object nondestructively. This information is crucial when developing a conservation plan.

Figure 69. Digital images of encrusted small sword hilt (Artifact No. 12930). The parameters of the CT scan are controlled by the CT technician. The computer allows us to view the artifact as a three-dimensional object. *Photo by J. Kampfl.*

Despite the diagnostic benefits to artifact conservation, the application of CT technology is somewhat limited by economic and logistical reasons. The cost of establishing CT radiography equipment in a conservation laboratory is considerable. Obtaining the necessary software applications and technical training can also prove extremely costly and time consuming. Even well-equipped laboratories with extensive budgets can experience problems if the required radiography equipment is not readily available or accessible (Politis et al. 1993:813-816).

As I proceeded with the first two case studies, I discovered that my options, in terms of available software applications was limited. The two leading three-dimensional software applications on the market at the time *Rapidform* and *Mimics 7.3,* proved adequate for my research. Both *Rapidform* and *Mimics* were capable of creating accurate 3D models of artifacts from optical, 3D scanning or CT devices, however the size, shape, and overall condition of the pre-conserved sword grip made it far easier to manipulate the CT digital data using the *Mimics* software. One advantage the *Mimics 7.3* software package had over the *Rapidform* software, was that *Mimics* was designed specifically for technical CT applications. *Mimics* is a software application that interpolates the image slice in very thin layers, and interfaces directly with most rapid prototyping systems. The *Mimics* software has the ability to define specific regions of the object, and easily display the segmentation results provided an excellent contrast between different materials which comprise the sword grip. Though the gray value interpolation is recommended when using technical CT image processing applications, *Mimics* also generates high-resolution 3D renderings in different colors directly from the CT slice information, which aids in the 'separation' of the various elements comprising the scanned object.

The ability to capture the geometry and surface information of cultural material and quickly measure, modify or even physically recreate them makes this technology an indispensable part of the conservators toolkit. The software and peripheral equipment is costly and does require some amount of training to use with any degree of efficiency. CT or other x-ray devices are not always readily available, and generally any use of such equipment is reserved for special case artifacts.

When deciding on a software package to use in conjunction with CT or laser scanner data; the conservator would be wise to consider, among other things; the overall cost of the software, ease of installation, compatibility with basic PC units, and the ability of a software application to interface properly with other software and hardware systems, and rapid prototyping printers. Does the software include the necessary features required by the conservator to achieve the desired outcome of any given project, and how does the software measure up in terms of user friendliness?

More recent developing technologies such as rapid prototyping methods and apparatus, laser scanner devices, and three-dimensional modeling software, work in conjunction with radiographic data making it possible to fabricate accurate replicas of artifacts with a minimum amount of risk to the artifact. Nevertheless, we are still dealing with an imperfect technology.

There are a number of rapid prototyping technologies available on the market. Considerations to be taken into account when purchasing a printer include: accuracy, durability of the machine, stability, feature definition, speed, material shrinkage, and model production cost. Of course, the end result of the rapid prototyping process is dependent on the quality of the model created using CT scan information and three-dimensional software. The key breakthrough is the ability to non-invasively reproduce physical three-dimensional models from CT scan data of irreplaceable archaeological artifacts (Morigi et al. 2010:653-661).

CHAPTER VII

CONCLUSION

Though the equipment and computer software used in these case studies was state-of-the-art, we are still dealing with an essentially imperfect technology, and of course imperfect human operators. In the future, the development of new and less expensive technology, such as photographic imaging for 3D printing, specific to the requirements of the conservator, may resolve some of the however conservators will still have.

The dimensional aspects of any object subjected to an underwater environment will undergo drastic changes: wood will swell and shrink, metal will often be reduced to slush through the corrosion process, etc. The accuracy of detail and scale of models either created using three-dimensional software, or models constructed using rapid-prototyping technology can only be measured in terms of degrees and approximates (Venuvinod and Weiyin 2004:227-234; Halim et al. 2005:1-10; Brown and Pestle 2006).

Conservation professionals aid in the recovery of fragile artifacts, and the analysis of artifact materials. Perhaps the most important task of the conservator is to preserve in any way possible the diagnostic attributes of an artifact. This includes the long-term stabilization, preservation, and possible reconstruction of artifacts by casting or any process which allows for additional research and future interpretation. Working in concert with archaeologists, historians, museum and various technical experts, conservators must be able to implement comprehensive and extensive documentation procedures, as well as maintain a current and working knowledge of the pertinent areas of science and materials research. The conservator must possess the ability to identify and adapt current and developing technologies to the task of artifact conservation and preservation.

Every artifact possesses a considerable amount of information about the materials and techniques used to manufacture the object, the manner in which it was used, the reasons for which it was ultimately discarded or lost, and the other artifacts with which it was deposited. An extensive analysis of the artifact remains can reveal the nature and cause of the artifacts decay and material breakdown. Conservators, perhaps, have the greatest opportunity to study and evaluate recovered artifacts, performing various material analysis, and formulating new stabilization and preservation treatments while increasing their data output. The detailed documentation and data accumulated during the conservation process can and should be archived; making it easily accessible by both scholars and the inquiring public.

Although many people regard archaeology as synonymous with excavation, it is far more than that. It also involves analyzing the material past with the aim of reconstructing that past as fully as possible. These remains or artifacts are the focus of the archaeological conservator. The general purpose of archaeological conservation is to study, record, stabilize, and restore the culturally significant qualities of any archaeological object with the least possible intervention. A great deal of my dissertation research centers around the ability and necessity of applying established conservation techniques, and newly developing technology to aid in the conservation and analysis of the swords from *La Belle*.

The conservator is dedicated to maintaining the long-term preservation of cultural artifacts through examination, documentation, treatment, and preventive care and research. Conservation is an interdisciplinary field involving knowledge and skills acquired from a number of diverse disciplines in the arts and sciences. As a result, conservators must have a working knowledge of materials science, chemistry, biology, physics, art history, and archaeology. Collaboration with those involved in medicine, engineering, computer science, and other technical fields is critical to the successful practice of conservation; making the preservation of our past a truly interdisciplinary endeavor (Figure 70). In the end, it is clear that anyone who dedicates themselves to the conservation of our material culture, must possess a great deal of knowledge, exceptional skill, and even a degree of imagination and a lot of improvisation abilities.

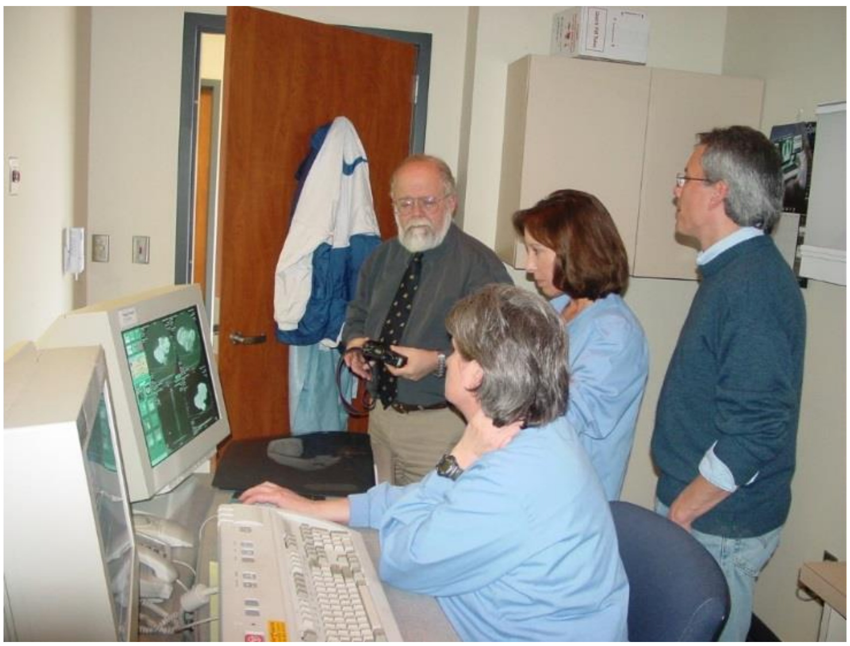

Figure 70. From left to right: Dr. Wayne Smith, Texas A&M University, Mammography Technologist Marsha Kampfl, Jeffrey J. Kampfl, and CT Technologist Carry White of The Physicians Centre discuss the first series of CT scans on one of the *La Belle* small sword hilts. *Photo by J. Kampfl.*

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APPENDIX A

LA SALLE CREW MEMBERS LISTED

AS SERVING IN A MILITARY CAPACITY

Surname	**Name/Title**	**Military Rank**	**Prior Military Service**
Barbier	Gabriel	Lieutenant	Unknown
Beaujeu	Taneguy Le Gallois de	Captain *Le Joly*	33 Years Army/Navy
Bihorel		Captain (Junior)	Unknown
Breman		Soldier	Unknown
Cavalier, de La Salle	Robert	Commander	Colonial Service
Moranget	Colin Crevel de	Lieutenant	Uknown
Duhaut	Pierre	Sergeant	Unknown
Fontain		Soldier	Unknown
Guichard		Soldier	Unknown
Joutel	Henri	Second In Command	16+ Years Army
La Jeunesse		Soldier	Unknown
La Sablonniere	Le Chevalier de (Marquis)	Lieutenant	Uknown
Le Clercq		Soldier	Unknown
Liotot	Etienne	Surgeon-Major	Unknown
Nicollas	Jacobus	Cannoneer (Gunner)	Uknown
Talon	Lucien	Soldier	Unknown
Turpin		Soldier	Unknown
Valigny		Captain (Senior)	Uknown

APPENDIX B

GLOSSARY OF SWORD COMPONENTS

Sword Hilt	
Arms of the Hilt	The loops or metal rings extending from the quillon block towards the ricasso, provides additional protection for a finger extended over the guard for extra blade control. Also referred to as annellets.
Cross Guard	A straight metal bar between the grip and shoulder of the blade, used to protect the hand. Associated with Medieval swords, the cross guard would eventually develop into the quillons of the rapier and small sword.
Ferrule	A metal or wire band located at the top and bottom of a sword grip, used to help keep the grip cover in place
Finial	The knob located at the end of each quillon, often worked or decorated.
Grip	The handle of the sword, fashioned from a variety of materials such as wood, metal, bone, or ivory. The shape and size of the grip varies from sword-type to sword-type.
Grip Cover	A material such as leather or shagreen, a type of untanned rawhide or shark skin, used to secure the hand-grip of the swordsman. Often augmented by strands of twisted metal wire.
Guard	Part of the hilt designed to protect the hand. Guard types range from the simple, Medieval cross-guard to the more complex and ornate rapier guards consisting of one or more metal bars, a metal 'cup' or 'basket,' or possibly a thicker, circle or bilobate-shaped guard found on most small swords.
Knuckle Bow	A curved metal bar extending from the pommel to the quillon block. The knuckle bow protects the hand from a slicing or hammering blow.
Pommel	The pommel serves as a counter-weight and also secures the hilt assembly to the blade. The size and shape of the pommel varies considerably and is often determined by sword type.
Pommel Cap	A small metal cap covering the opening at the top of the pommel. If the tang of the blade is peened over the pommel, the pommel cap may be welded to the pommel. If the tang is threaded, the pommel cap will screw on securing the pommel to the hilt assembly.
Quillon	Two metal bars extending outward from the quillon block. Designed to protect the fingers and hand. Quillons may have developed from the medieval cross guard.
Quillon Block	Large, hollow metal piece to which all metal hilt components are attached. First section of hilt assembly to slide over tang, resting on the shoulder of the blade.
Washer	Threaded piece of metal used to secure the quillon block to the lower guard.

Sword Blade	
Blade Ridge	A raised central spine running down the flat of a two-edged blade. Used to strengthen the blade.
Edge	The sharpened portion of a blade used for cutting and slashing blows.
Foible	The lower section of a sword blade. On thrusting weapons, the narrow, thinner section of the sword blade, which allows for quicker, more accurate thrusting attacks.
Forte	The stronger, reinforced section of the blade located just below the guard, used to parry attacks.
Fuller	Shallow groove running down central portion of blade, reduces the weight of the blade while maintaining its strength.
Point	Tip of the sword blade. Width and shape of point depends of the type of blade.
Ricasso	Thicker, unsharpened section of the blade located at the base of the blade just below the guard.
Shoulder	Base of sword blade where the hilt meets the blade, separating the blade from the tang.
Tang	Thin, narrow section of blade running through the grip, attached to the pommel.
Terzo	Middle section of the blade, located between the forte and foible.

Sword Scabbard	
Carrying Ring	One or two rings located between the scabbard mouth and chape. Also referred to as suspension rings, a chain or strip of leather from a sword belt or baldric is attached to the rings, which facilitates the carrying of the scabbard.
Chape	The metal piece located at the end of a scabbard. Also referred to as a drag, this piece protects the scabbard from damage while it is in use.
Finial (Scabbard)	A pointed metal piece used in place of a scabbard chape.
Middle Bands	Metal bands around the scabbard to which the carrying rings are attached.
Mouth Piece	Metal piece which protects the opening of the scabbard.
Scabbard Hook	A metal hook designed to secure the scabbard to a belt or baldric
Throat	A metal piece attached to the scabbard mouth designed to protect the scabbard opening

APPENDIX C

SMALL SWORD TERMINOLOGY

Small Sword Hilt	**Alternate Terminology**
Arms of the Hilt	Eyes of the Hilt, Annellets, Finger Ring, Pas d'ane
Ferrule	Turk's Head
Finial	
Grip	Handle
Grip Cover	Wire Wrap
Guard	Shell Guard, Coquille Guard
Knuckle Bow	Knuckle Guard
Pommel	
Pommel Cap	Capstan Rivet, Pommel Nut, Pommel Screw, Tang Button, Tang Nut, Top Nut
Quillon	
Quillon Block	Ecusson, Sleeve
Washer	Mullet

Small Sword Blade	**Alternate Terminology**
Blade Ridge	Spine
Edge	
Foible	
Forte	
Fuller	Flute, Blood Groove
Point	
Ricasso	Heel of Blade, Shoulder of Blade
Tang	
Terzo	

Small Sword Scabbard	**Alternate Terminology**
Carrying Ring	Scabbard Suspension Ring
Chape	
Finial	Button
Middle Band	Scabbard Reinforcement Ring
Mouth Piece	
Scabbard Hook	Carrying Hook, Frog Stud
Throat	Locket

APPENDIX D

SMALL SWORD

MULTI-LINGUAL GLOSSARY

English	**French**	**Italian**	**Spanish**
Arms of the Hilt	Annelet	-	-
Blade	Lame	Lama	Hoja
Blade Ridge	arête, méplat	-	lomo de Anguilla
Carrying Ring	Bélières	campanella	anilles de la vaina
Chape	dard, bouterolle	strascico, puntale	Contera
Edge	Trenchant	Filo	Filo
Ferrule	bagues de fusée	Ghiera	virola, casquillo
Finial	-	-	-
Finial (scabbard)	bouton de bouterolle	-	botón
Foible	Faible	-	flaco
Forte	Fort	-	alto, fuerte
Fuller	Cannelure	scanalatura	vaceo, canál
Grip	Poignée	impugnatura	puño
Grip Cover	monture, fusée	Rocchetto	-
Grip Wire	Filigrane	Spire	alambrado
Guard (shell)	garde,coquille,rondelle, pontat	guardia	cáchas
Hilt	monture, poignée	Elsa	empuñadura,
Knuckle Bow	amande, branche principale	elsa di guardia	aro, guardamonte
Middle Band	Bracelet	fascetta	abrazadera
Mouth	Bouche	bocchetta, bocca	boquilla para vaina
Point	pointe, estoc	punta	punta
Pommel	pommeau	pomo	monterilla, pomo
Pommel Cap	pommeau, calotte	contropomo	perilla
Quillon	Quillon	Elsa	gavilan, gavion
Quillon Block	noeud de croisière, écusson	-	Cruz
Ricasso	ricasso de la lame	Tallone	bigotera
Scabbard	Fourreau	Fodero	sable
Scabbard Hook	crochet de fourreau	-	botón
Small Sword	monture a'la mousquetaire	-	espadin
Tang	Soie	Codolo	espiga
Terzo	Terzo	Terzo	Terza
Throat	Battes	fascetta di bocca	Gola
Washer	Plateau	-	Bigote

TEXAS HISTORICAL COMMISSION
real places telling real stories

December 21, 2018

Mr. Jeff Kampfl
2705 W. Sesame Street
Dunlap, Illinois 61525

Dear Jeff,

The THC has reviewed the forwarded images that you wish to include in your dissertation and we grant permission for their use. Congratulations on the completion of your study!

Sincerely,

Amy A. Borgens
State Marine Archeologist, Archeology Division.