A NECESSARY DUTY, A HIDEOUS FAULT:

DIGITAL TECHNOLOGY AND

THE ETHICS OF ARCHAEOLOGICAL CONSERVATION

A Thesis

by

MEGAN HATHAWAY SMITH

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

MASTER OF ARTS

May 2010

Major Subject: Anthropology

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Approved by:

Chair of Committee,	Charles W. Smith
Committee Members,	Luis Vieira de Castro
	Robert B. Warden
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ABSTRACT

A Necessary Duty, A Hideous Fault:

Digital Technology and the Ethics of Archaeological Conservation.

(May 2010)

Megan Hathaway Smith, B.A., University of Colorado at Boulder

Chair of Advisory Committee: Dr. Charles W. Smith

Archaeological conservation is the process by which conservators prevent deterioration of archaeological remains and provide insight into the nature of recovered material. This thesis examines the effect of digital technology upon the ethics of the conservation profession and upon the attitude of the lay-public towards archaeology. The ethical issues raised by the use of digital technology are discussed, particularly the ways in which these issues differ from those raised by traditional conservation methods.

Technological advancements, particularly those occurring in the 20th century, changed the way artifacts are conserved and studied. Conservation arose out of a craft-restoration tradition and evolved into a profession which, in addition to necessary artistic and aesthetic considerations, uses a demonstrable scientific method in order to preserve artifacts. The creation of guidelines for practice and various codes of ethics is the turning point in this evolution, marking the point after which conservation became a scientific profession.

Advances in computer technology have permitted the widespread use of devices such as 3-D scanners, digital CT scanners, and digital cameras in the conservation of archaeological artifacts. All of these pieces of equipment produced digital files which must be stored. Currently, the pace of technological change renders most data inaccessible within ten years, and data conservation problems such as storage, access, and file format have not been adequately addressed by the professional conservation community. There is a distinct lack of formal ethical guidelines concerning these issues; this thesis concludes that there is an extreme need for measured consideration before digital methods are used in archaeological conservation.

The creation of high-fidelity replicas presents a problem for the museum audience. The public connects with artifacts on an emotional level which is altered when a replica is displayed instead of an original. Digital reconstructions abound in popular culture, heavily influencing public opinion, and often resulting in widespread misperception of the information which can be extracted from archaeological evidence. As a result, conservators of the future must be cautious when creating digital artifacts, and must be meticulously careful to make the nature of digital reconstruction clear to the audience, in order to avoid spreading misinformation.

DEDICATION

To my family

Fortitudine vincimus

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TABLE OF CONTENTS

CHAPTER I

INTRODUCTION: CONSERVATION AND TECHNOLOGY

Advancements in archaeological conservation technology over the course of the 20th century have radically altered both the profession of conservation and the manner in which archaeological artifacts are approached for preservation treatments. Conservation has evolved from the duty of the archaeologist into a scientific process with a demonstrable method, carried out by specialized practitioners. Despite this specialization, the influences on the field still come primarily from the vocations in which it originated, namely architectural and fine art conservation.

Conservation, as a general term, is best defined as the preservation of cultural heritage for the future. Conservation is carried out through specific actions including examination, documentation, treatment, and preventive care (Appelbaum 2007:xix-xxi). Archaeological conservation uses these actions in order to preserve and interpret information from material recovered during archaeological excavations. The primary goal of archaeological conservation is to prevent deterioration of the artifact and to help researchers investigate and understand the true nature of recovered material (Cronyn 1990:1, 4).

A main difference between standard object conservation and archaeological conservation is that the preservation of artifacts must begin at the moment of excavation in order to avoid deterioration and loss of information. The most information will be

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This thesis follows the style of *Historical Archaeology*.

extracted from the object during laboratory conservation activities, but the object must survive intact in order to yield usable data upon examination in the lab (Cronyn 1990:5-6). Often, field conservation takes place in less than ideal conditions, which is not typical for the conservation of paintings and other fine art objects.

Art conservation as a science arose out of the craft tradition of restoration. During the 18th century, after the discovery of Pompeii and Herculaneum brought ancient artifacts to the attention of modern society, these artifacts were cleaned and restored just as if they were works of art. The perception of artifacts as works of art has been slow to change, but the passage of time has drastically altered the conservation-restoration profession. Inquiries into chemical and scientific means of preserving ancient artifacts slowly generated a demonstrable conservation methodology, which is now conveyed to students by means of education and training. While conservation still retains its artistic roots, it is now considered a scientific profession by its practitioners, and conserved objects – artifacts especially – routinely undergo examinations and research guided by the scientific method.

The scientific outlook has created a new way of treating artifacts. Each object recovered from an excavation is considered in an empirical light, valuable for the information which can be gained from it. In this model, each object conveys information about the culture from which it came, but this information can only be retrieved by scientific analysis. As technological advancements offer new and different methods of analysis, the questions asked in the course of archaeological conservation change in response, as do considerations regarding the impact of intervention and testing on artifacts.

Advances in technology now allow an artifact to be scanned into a computer and reproduced via computer modeling and 3-D printing. A printed replica of an artifact may be put on display and may not be discernible from the original unless the museum includes explicit details about the object. These new methods of conservation and documentation are exciting and capture the public's imagination, but these techniques hold ethical dilemmas which have not been adequately considered by the professional conservation community. The question of whether the intrinsic value of the original is lost or compromised when reproductions are put on display has received some attention; unfortunately the ways in which the reproduction of an artifact affects the conservation efforts on the original object are seldom examined in detail. The strong links between the fine art and architectural conservation fields and the practice of archaeological conservation influence the ways in which the ethics of conservation practice are understood. Due to these influences, the ethics of technology as used in archaeological conservation have yet to be well defined and closely examined. In particular, the literature lacks mention of the ways in which certain ethical questions – specific to archaeological conservation – raised by digital techniques differ from those arising from traditional analog technology.

Most authors spend time tracing the evolution of conservation into a science and the ways in which the ethics of conservation have changed in response, but fail to address the role of digital technology in modern, ethical practice. A challenge lies in attempting to understand archaeological conservation separately from fine art or architectural conservation. The practice of conserving artifacts arose from these fields, but while these disciplines have stated codes of ethics for the practice of their individual brand of conservation, the specialized practice of conserving archaeological remains follows no specific, declared ethical mores. Particularly in the United States, archaeological conservation inhabits its own vague territory, remaining in limbo between science and an art.

This thesis examines the evolution of conservation into a scientific discipline and relates the resulting scientific attitude to the ways in which technological advancement has influenced the questions asked of artifacts and the treatments used upon them. In addition, this thesis inspects the differences between the ethical issues raised by the use of digital technology and those encountered during traditional conservation treatments. These concepts will necessarily be explored within the historical context of architectural and fine arts conservation. The idea of minimal intervention will be addressed within the framework of technological influences, as will the ethical problem posed by limited financial means. Technologically complex treatments cost money. The question of whether it is ethical to undertake a less expensive treatment on an artifact when a more effective, more costly treatment is available must be considered in a conservation plan. Further, how artifacts are selected for advanced technological treatment over other artifacts is a question in need of answering, since selection for conservation conveys meaning and value upon the artifact being conserved (Swade 2003:273; Clavir 2002:31, 42).

The nature and limitations of digital technology, as it is currently used in the conservation field, have received limited attention. At the current moment, digital technology is a tool which is most useful for allowing widespread access to data, and for fast, easy photographic and image documentation of objects before, during, and after conservation (Kushel 2002:2002). These activities generate massive amounts of digital data which, if conservators wish to behave in a manner consistent with the stated ethics of the profession, must be preserved alongside the object undergoing conservation treatment. This necessity for preserving the data raises many difficulties, the chief of which are the lack of reliable formats for digital archiving, and the rapid evolution and obsolescence of digital technology. These problems and some potential solutions are assessed, along with the implications for the conservation profession.

The final point of inquiry is whether technology, such as digital scanning and printing of objects so that a replica may be used for display in place of an original item, compromises the public's relationship with their material heritage. The replacement of an object with a replica reduces the cultural relevance of the artifact and substantially changes the public's emotional reaction to the exhibit (Barassi 2007). The widespread use of digital reconstructions in museums and on television shows around the world raises similar issues, particularly since these images are often "over-restored", and the lay-public has no easy means of distinguishing the accurate parts of the reconstruction from those which are inaccurate or have been manipulated (Swade 2003:276). The use of digital images often negates a sense of "reality" for the audience, since it is difficult to make a physical and emotional connection with an image on a screen (Rountree et al. 2002:133).

Tracing and understanding the changes effected by digital technology in relation both to the conservation and display of archaeological artifacts, and the relationship of the public to such artifacts, will shed light on the ways in which ethical guidelines for archaeological conservation should address the use of digital technology for conservation in the future.

CHAPTER II

EVOLUTION OF A SCIENTIFIC PROFESSION

Archaeological conservation has its roots in the restoration traditions of art and architecture. For centuries, archaeological artifacts such as statues were considered to be fine art, rather than artifacts representing the material culture of their original civilization. When these “works of art” were excavated in an incomplete condition, or if they became damaged, various artisans oversaw their repair or restoration. Such repairs usually involved changes to the nature of the object in order to preserve its aesthetic integrity at the expense of its original appearance or function. This form of restoration was not approached as a science, but as an art form, with aesthetic considerations being of chief concern.

The Laocoön group, a sculpture extensively repaired after its excavation in 1506 and now displayed in the Vatican Belvedere courtyard, is a good example of early restoration attempts. Artists provided various sketches showing what they believed to be the proper orientation. The winner filled in the missing elements of the sculpture to create a visually cohesive work of art. The restoration proved inaccurate after archaeological excavations in 1905 unearthed an original section of the statue with a different orientation than any of the proposed Renaissance reconstructions (Barkan 2001:9). The Vatican Museum staff removed the Renaissance restorations and replaced them with the fragment in the 1950s; other non-original sections of the group were removed and not replaced after this refurbishment. Even after these removals, the original orientation of the sculpture remains a point of contention because of the number of changes made to the figures over time (Howard 1989:417).

The rediscovery of the buried Roman towns of Pompeii and Herculaneum in the second half of the 18th century produced an influx of artifacts into the art collections of Bourbon nobility (D'Alconzo 2007:204). Wall paintings were habitually decontextualized. For example, small figurative scenes prized for their art value were cut from the walls of well preserved rooms, not because of the difficulty of removing large sections of plaster, but because the aesthetic tastes of the 18th century valued individual scenes rather than entire frescoes (D'Alconzo 2007:204-205). Even ordinary artifacts such as bottles and pottery entered various collections as *objets d'art*. The attention these unique sites and finds received began to arouse international interest in methods of preservation (Sease 1996:157). The desire to make archaeological artifacts – which were, naturally, excavated in various states of degradation – clean and whole in order to view them in their "real" state reflected the social value placed on restoring objects and creating a coherent aesthetic. While it took time, the value which archaeologists placed on the actual physical remains of artifacts, rather than their aesthetic appearance, influenced conservators, who began to emphasize the physical integrity of an object and the need for a systematic and analytical approach to preserving it (Clavir 2002:8).

The first true attempt at archaeological conservation, rather than simple restoration, arose in conjunction with the examination of papyrus scrolls from the Villa of the Papyri in Herculaneum (Seeley 1987:163). Experiments designed to unroll the carbonized scrolls revealed how little was known about deterioration in archaeological contexts (Sease 1996:158), which inspired scientists to investigate new techniques for treating artifacts. Such investigations moved restoration closer to being a formal science; however, the scientists usually involved themselves with characterizing ancient materials – studying pigments, glass and metal in order to discover their composition. While concerned, to a degree, with the actual preservation of antiquities, initial scientific focus centered around the makeup of artifacts and the mechanisms of their decay rather than the information to be gleaned from their function or manufacture (Pollard and Heron 2008:4).

A truly scientific approach to preserving archaeological artifacts took several more decades to evolve, appearing in the work of Sir Humphrey Davy, a British scientist who endeavored to solve the problem of unrolling the Herculaneum scrolls (Seeley 1987: 164). Although scientists specializing in non-archaeological fields, such as chemistry and metallurgy, remained the main practitioners of artifact preservation, Davy's manner of study differed from the attitudes of previous generations of scientists. His methods involved a full assessment and understanding of artifacts' condition, methods of manufacture, extent of deterioration, and the nature of such deterioration rather than a focus on their constituent materials (Sease 1996:158).

Conservation as Science

On April 1, 1888, with his appointment as "chemist-in-charge" of the Chemical Laboratory of the Royal Museums of Berlin, Friedrich Rathgen became the first scientist permanently employed by a museum in a laboratory setting. The foundation of this chemical laboratory predated the establishment of a similar facility at the British Museum by 34 years (Gilberg 1987:107; Seeley 1987:166). The creation of the laboratory, and Rathgen's position, represents the beginning of the period in which science and technology addressed preservation problems in a formalized, professional setting, and marks the largest stride in the evolution from restoration to conservation.

Rathgen's approach to preservation followed some of the methods seen in Davy's work decades earlier. He made thorough observations of an artifact before beginning conservation treatments, noting manufacturing details, composite materials, and any areas of deterioration. Though he trained as a chemist, Rathgen devoted his entire career to preserving art and artifacts - a sharp contrast to the earlier scientists who worked on artifacts but were primarily devoted to their separate scientific disciplines. He was the first scientist in a permanent position created expressly for the purpose of studying and conserving artifacts as a whole. In comparison to later conservators, his treatment methods were rather primitive, approaching preservation as a matter of simply eliminating decay. Many of his contributions to the field remain in use, however, such as a method he devised for preserving unbaked clay tablets, and the use of synthetic agents as an alternative to traditional organic adhesives and consolidants (Seeley 1987:166-167).

Conservation in the Field

Despite Rathgen's historic appointment as the first archaeological conservator, the profession emerged slowly as an independent area of practice and did not truly resemble the type of conservation practiced in the current day. Scientific attitudes prevailed in the practice of preservation, and technology was applied to the problem of degradation, but the work was mostly confined to a few practitioners in a few major museums (Seeley 1987:166). Even decades after museum conservation began to transition to a systematic science, conservation work on artifacts – particularly work carried out in the field – often remained a task for excavators. Writing at the turn of the 20th century, Flinders Petrie devoted an entire chapter of his seminal work *Methods and Aims in Archaeology* to artifact conservation, clearly stating that the responsibility for preserving excavated finds lies with the person who finds them: “The preservation of the objects that are found is a necessary duty of the finder. To disclose things only to destroy them, when a more skilful or patient worker might have added them to the world’s treasures, is a hideous fault,” (Petrie 1904:85).

Matthew William Flinders Petrie was a self-taught British archaeologist and Egyptologist whose work revolutionized Egyptian and Near Eastern archaeology, and the process of archaeological excavation itself (Sease 2001:183). Petrie often worked without wages, for the sake of knowledge, rather than for the personal fame and monetary gain which motivated other excavators (Fargo 1984:221). Unlike many archaeologists of the time, Petrie meticulously recorded and worked to conserve all artifacts found on his excavations, insisting that everyday objects and sherds were as valuable to the study of the past as the large ornate artifacts which caught the public’s attention. This attitude, now adopted as standard practice on excavations, was slow to catch on within archaeology and the fledgling conservation field, and particularly with the public at large. The perception that archaeological artifacts are valuable only if they are large, beautiful, or made of precious materials continued to hinder the development of archaeological conservation, even after science was accepted as the basis for the practice of art and architectural conservation.

Over the course of his decades of excavation, Petrie found inventive and practical solutions to problems encountered during excavation, using only available tools and materials. While conservation science advanced in museum laboratories, field conditions meant few excavators had access to the kind of technology utilized in conservation labs (Sease 1996:159). More importantly, at that time few excavators invested the time or energy in their finds which is necessary for proper conservation (Fargo 1984:221). One of Petrie's favorite conservation materials was paraffin wax, which demonstrated the qualities he desired and searched for in a consolidant.

Portraits recovered with Roman mummies in Memphis presented Petrie with a challenge. The wax paint of the portrait flaked off the wooden backing when excavation exposed them to changing atmospheric conditions outside the archaeological environment. In order to save the portraits, they were coated with a thin layer of paraffin wax, because Petrie found paraffin to be "the only preservative which will not alter in the course of time, which is colourless, which retains the brittle paint by a tough coat, and which makes the whole damp-proof,"(Petrie 1911:6). Petrie also noted that the wax could be removed by gently reheating the treated portrait and it did not obscure the surface detail of the artifact while in place (Petrie 1911:6). Paraffin is not reversible by modern standards – that is, it cannot be completely removed while leaving the artifact beneath completely unchanged. Petrie's writing is, however, one of the first instances in which the most desirable characteristics of an ideal consolidant – namely the lack of color and alteration to the artifact, stability, reversibility, an inert nature, and the ability to impart long term protection to the artifact – are articulated. These qualities remain the desired ideal for conservation treatments even in the modern day (Sease 2001:184).

Although Petrie made significant advancements in archaeology, and was a pioneer of field conservation, he was not a fully dedicated conservator. He conserved the artifacts he unearthed, but his primary interest was archaeological. It was not until Howard Carter, who had been trained by Petrie, engaged a conservator named Alfred Lucas in the excavation of the tomb of Tutankhamen in 1923 that a member of an excavation was employed full-time to treat artifacts in the field (Sease 1996:159; Seeley 1987:168). Despite the efforts of excavators like Petrie and Carter, the general perception that archaeological artifacts were primarily objects of artistic value persisted. Conservators became common in major museums (Seeley 1987:168), but their focus centered on objects with artistic value, paintings in particular. The concept of conserving everyday artifacts for the information they contained had not yet gained widespread acceptance.

Various histories of conservation credit World War I with providing the impetus for major advancements in art conservation (Clavir 1998:5; Plenderleith 1998:129; Kavanagh 1994:170). In Britain, this impetus arrived in the form of major damage to various museum collections due to adverse storage conditions in wartime. In an attempt to keep the collections of the British Museum from being damaged during bombing, artifacts, paintings, and other objects from the museum were removed from the premises in 1918 and stored in sections of the London Underground (Caygill 1992a:32). While the most fragile artifacts were stored elsewhere, even the sculptures and other items considered robust enough for transport and storage suffered from the high humidity and unstable temperatures in the tunnels. Upon their return to the museum in early 1919, the artifacts showed signs of deterioration from mildew and salt crystallization, which had caused the loss of many features and decorative elements (Plenderleith 1998:129).

This damage prompted the Trustees of the British museum to seek help from the Royal Society, which suggested Dr. Alexander Scott as the most qualified person to carry out an investigation of the artifacts. Upon Dr. Scott's recommendation, the funds for an emergency laboratory were approved in 1920. In 1922 the laboratory itself, meant to last only three years, was established within the museum and directed by Dr. Scott (Plenderleith 1998:130). The extent of the damage was so great that three years was not adequate for its mitigation, and funding continued until 1931. At that time the Trustees finally recognized its great value, and it was permanently incorporated into the museum under the title of the "Research Laboratory" (Plenderleith 1998:130; Caygill 1992b:50). Many of the most important artifacts of the time were conserved at the lab, including artifacts from excavations at Ur, and others from the tomb of Tutankhamen (Plenderleith 1998:131; Seeley 1987:168). By the time Dr. Scott retired in 1933, the British Museum's conservation laboratory, funded extensively by the government, had become one of the most prominent in the world. The instability of the German state following the end of the war may also have contributed to the geographic power shift which occurred in museum conservation, as the German government did not have the funds or attention to devote to conservation research. London superseded Berlin as the focal point of innovation from that time on, and English became the principal language for publication in conservation (Clavir 2002:22; Kavanagh 1994:170).

Birth of a Profession

The first major international meeting of professionals who focused on the preservation of art and antiquities occurred in Rome in 1930. At this conference the professionals involved voiced their growing discontent with the ill-defined nature of conservation practice and insisted upon more explicit and rigorous standards for practicing conservators (Stout 1964:126). It also marked the beginning of a decade in which science was internationally accepted as the ideal method for solving problems encountered in conservation (Clavir 1998:3). While the conference began to define conservation as a profession, it also emphasized a growing rift between the conservation of archaeological artifacts and the preservation of architecture and works of fine art. The official title, highly indicative of this separation, was "the International Conference for the Study of Scientific Methods for the Examination and Preservation of Works of Art," and the topics to be covered were divided into two sections, one covering paintings, and the other, sculptures (Plenderleith 1930:1). Since conservation originated with the repair of items valued for their aesthetic properties, it is not surprising that attention remained centered on paintings and those artifacts which had value as *objets d'art*. It is at this point that the science of conservation began to separate into distinct, parallel fields consisting of fine art, architectural, and archaeological conservation. Over the next decades, and with only a few notable exceptions, art conservation dominated the profession.

One of the most noteworthy exceptions was the publication in 1934 of pamphlets which formed the later basis for one of the “Bibles” of conservation (Plenderleith 1998:133). Within these pamphlets Harold Plenderleith, by then the director of the conservation laboratory of the British Museum, laid out treatment plans for a variety of objects, including archaeological artifacts. In the years immediately before the Second World War, studies of relative humidity revolutionized the field of preventive conservation; the wartime storage of the British Museum’s collection after evacuations in 1939 reflected the newfound realization that a temperature and humidity controlled environment reduced mold growth, paint blistering, and a host of other problems (Plenderleith 1998:132, 135).

In the wake of World War II, the foundation of the United Nations and subsequent creation of UNESCO paved the way for the establishment of several international, non-governmental organizations concerned with museums and conservation. In mid-August 1946 the commission responsible for issuing reports and recommendations to the Executive committee of UNESCO noted the absence of an international service for museums, and considered establishing such a service. Chauncey J. Hamlin, at that time chairman of the American Associations of Museums Policy Committee, initiated the formation of national committees of museums throughout Europe within the month, and by October 1947 this International Council of Museums

(ICOM) was given oversight of UNESCO's museum regulations and activities (Cannon-Brookes 1997:198-199). ICOM began publishing *MUSEUM*, a quarterly journal concerning technical, museographical issues from every discipline which appears currently under the name *MUSEUM International*. Conservation, at that time an activity carried out chiefly in museums, figured in its concerns, but was not a main focus.

In 1959 a joint initiative by UNESCO and ICOM created the International Center for the Study of Preservation and Restoration of Cultural Property in Rome (Cannon-Brookes 1997:200). The center was later re-named ICCROM, standing for the International Center for Conservation, Rome, as the original moniker was too unwieldy (Plenderleith 1998:137). ICCROM was designed to work closely with both ICOM and UNESCO and to focus on the conservation of objects in all settings, outside of the museum-centered focus found in the general publications and work of ICOM. Dr. Plenderleith retired from his post at the British Museum to become the director of the Foundation for the next 14 years (Plenderleith 1998:137). Students from around the world travelled to Rome to receive specialized training in all areas of preservation and conservation, and ICCROM continues to focus on training students and disseminating knowledge about advances in conservation.

The repatriation of art treasures after the end of World War II opened discussions between various experts regarding the need for an avenue of information exchange and the revival of *Technical Studies*, a defunct publication of the Fogg Art Museum at Harvard University. From these meetings, which began in 1946, a second international organization concerned with conservation arose in 1950. Initially named the

International Institute for the Conservation of Museum Objects, its title was changed in 1959 to the International Institute for Conservation of Historic and Artistic Works (IIC) (Plenderleith 1998:135; Stout 1964:127). As a functional “midpoint” between the United States and continental Europe, London became the headquarters of the newly formed Institute and George Stout, a former researcher at the Fogg Art Museum, became its first President. The IIC was concerned with the status of conservators, the publication of scientifically based technical work, and the training of students with the aim of eliminating the secrecy which surrounded many works of restoration in the past (International Institute for Conservation of Historic and Artistic Works [IIC] 2009). The successor to *Technical Studies*, titled *Studies in Conservation*, first appeared in 1952, and the IIC holds international conferences at two or three year intervals, publishing the papers from each conference to insure that advances in conservation are adequately shared among practitioners (IIC 2009). The subject matter of *Studies in Conservation*, especially in its earliest days, focused heavily on the conservation of paintings and art objects, setting the tone of the conservation profession for the next decades.

In 1956 Harold Plenderleith published an expanded and more comprehensive version of his earlier conservation pamphlets entitled: *The Conservation of Antiquities and Works of Art, Treatment, Repair, and Restoration* (Pease 1957:191; Plenderleith 1998:133). Used as a basic handbook of techniques for decades, it remains one of the seminal texts in the field (Sease 1996:160). Plenderleith’s work is unique in that he mentions both the conservation of archaeological artifacts and fine art objects equally, recognizing that a fine balance must be reached when satisfying the requirements of science, art, and archaeology (Plenderleith 1970:viii). The book provides instructions on conserving objects ranging from archaeological bone to paintings, but generally assumes that archaeological objects will be conserved in a museum setting, rather than at the site of excavation; many of his recommendations require access to chemicals and equipment not generally available in the field (Plenderleith 1971:155-156). After this point, archaeological conservation fades into the background of conservation practice and literature for several decades. Artifacts were excavated, conserved, and studied, but major advances of the practice, and ethical discussions regarding restoration and conservation, were dominated by fine art conservation, with some contributions from the architectural field.

Ethics and Professionalism

In 1930, the demands made at the Rome conference for more rigorous standards began a process of professionalization which eventually culminated, decades later, in the creation of codes of ethics and practice for the conservation field. The *Murray Pease Report*, adopted by IIC-American Group in 1963, was the first international standard of practice in conservation (Sease 1998:99). Before this, the ethical ramifications of conservation were generally contemplated only by the individual practitioner in question; the goal was to eliminate decay and provide an aesthetically pleasing object for display, rather than to consider the degree to which such interventions affected or should affect each item. Over-cleaning and over-restoration were common (Clavir 2002:8-9;

Bomford 1994:36), and no oversight or practical methodological guidelines existed for conservators practicing their craft outside of the museum environment.

Codes of ethics and standard practice function as a way to distinguish illegitimate from legitimate practitioners of a profession (Wildesen 1984:7). Though it took more than three decades for conservators to refine their ethical and practical standards, the Rome conference of 1930 stands as the delineation point, after which the “restorer” or “preserver” of artifacts becomes legitimately a “conservator”. The conference is the foundation of true professionalism, as certain practitioners sought to distance themselves from a developing stigma attached to the restorers of the past and to more accurately define the actions and methods used when treating an object (Hulmer 1955:85). The conference also helped establish professional working relationships which significantly influenced the later foundation of several professional conservation organizations (Boothroyd-Brooks 2000:3).

Changing social processes after World War II facilitated the movement in favor of professional differentiation with increased university salaries. Prior to this time, archaeology and conservation were generally the preserve of the wealthy, since they had the time and resources necessary for both education and excavation without attempting to survive on the insignificant income provided by a university position (Rotroff 2001:138). After the war, university salaries provided a living wage, and more people could afford to enter the fields of archaeology and conservation. Monuments and works of art damaged during wartime needed to be documented and repaired, and the number of archaeological excavations increased rapidly. The combination of damaged objects and new artifacts from excavations increased the demand for people able conserve these items. The resulting influx of people practicing conservation without a formal education or specific knowledge of the field raised concern for the wellbeing of artifacts, and gave rise to a number of organizations designed to formally characterize and define the profession to outsiders. Such organizations often function as a way not only to formally define a vocation, but also as a way to express to students and other aspiring practitioners the magnitude of the occupation they wish to enter (Wildesen 1984:4).

The foundation of IIC in April of 1950 was the first manifestation of the professional organization in conservation. Various national groups of the IIC later broke away from the parent institution in order to become independent professional organizations: the IIC-American group later became the American Institute for Conservation (AIC), the IIC-Canadian group is now the Canadian Association of Conservators (CAC), and the Australian IIC group is the Australian Institute for the Conservation of Cultural Material (AICCM) (Sease 1998:99). The creation of these groups began the process of formalizing expectations for professional practice; official ethics documents appeared within a few years of their foundation.

Formal Codes of Ethics

In June of 1963, the IIC-American Group (IIC-AG) became the first of these conservation groups to define the ethics of conservation practice in a widely published document known as the *Murray Pease Report*. This report, created by a specially appointed committee on professional standards and procedures, arose in response to a remark at the Rome Conference in 1961 by Dr. A. van Schendel, then president of the IIC-AG. He asserted that "one of the important distinguishing features between the craft and professional phases is that in the latter there is an accepted corpus of principles and methods," (IIC 1964:116). This comment demonstrates the role that explicated, codified group standards were expected to play in the practice of professional conservation.

The document itself did not attempt to define the basic moral obligations which applied to professional activity in conservation, but described appropriate steps which should be undertaken in normal circumstances (IIC 1964:116). While it was a great step forward in terms of formalizing appropriate conservation protocol, the *Murray Pease Report* was specifically concerned with the conservation and protection of "works of art"; nowhere in the document are archaeological artifacts mentioned. The report made it obvious, however, that conservators accepted the obligation to conserve whatever object came to them for treatment. While archaeologists still supplied the funds for conservation work, in the eyes of the conservation profession the necessary duty of conservation was no longer the sole responsibility of the excavator.

The AIC formally adopted its *Code of Ethics for Art Conservators*, based on the recommendations and ideas found in the *Murray Pease Report*, in 1968 (Sease 1998:99). The other national groups of the IIC were slower to adopt formal codes of ethics. The UKIC first adopted a code in 1982. The AAICM and CAC followed in 1986. Internationally, the movement towards ethical guidelines which would apply to conservators worldwide received a boost in 1984 when the International Council of Museums Committee for Conservation (ICOM-CC) published *The Conservator-*

Restorer: A Definition of a Profession (International Council of Museums Committee for Conservation [ICOM-CC] 1984). This document outlined the basic skills and education required of the profession, including training in ethics. It does not, however, give specific ethical guidelines for practitioners, and an internationally accepted code of ethics for the conservation field remains an elusive ideal.

In each institution which has adopted a code of ethics, the code is connected with a more detailed document outlining good conservation practice, and the documents are utilized together as composite parts of a single entity (Sease 1998:99). These guidelines for practice contain more explicit information about the behavior constituting ethical conservation than do the codes of ethics. The AIC's guidelines for practice contain extensive commentaries designed to "provide accepted criteria against which a specific procedure or operation can be measured when a question as to its adequacy has been raised," (American Institute for the Conservation of Historic and Artistic Works [AIC] 1994).

While these directives provide some guidance for conservators as they perform their work, no code of ethics or guideline for practice produced by either conservation or archaeological organizations attempts to mandate specific behavior on the part of its members. The nature of conservation organizations makes such a mandate impossible. For some organizations, such as a state bar association, membership in the group is compulsory for professional practice. In conservation, violation of the ethical guidelines of the profession may result in the disapproval of other practitioners, but it does not preclude professional practice. The vague, overarching ideal within the guidelines is that each conservator should aim for the best possible practice (Rotroff 2001:140), which has also been interpreted by one author as an imperative to “do what is in the best interest of the object without compromising its tangible as well as its nontangible aspects,” (Sease 1998:102). This vagueness has particular repercussions for archaeological conservators (see below, p. 26).

Early versions of practical ethics guidelines stressed that each object should receive the same quality of treatment, making no allowances for the particular significance of each item. Most archaeological projects have limited funds for conservation, making this ideal impractical. The AIC’s guidelines shifted in recognition of this impracticality, and now simply state that the quality of the conservation work should not be compromised by lack of funds (AIC 1994). There is a notable paucity of ethical guidelines laid out specifically for archaeological conservation. No delineations between artifacts and art objects appear in the conservation guidelines, and the specific problems inherent to the conservation of archaeological objects are not well defined. This absence is partially due to the nature of the conservation field and partially because of a major shift within archaeology which occurred over the course of the 20th century.

The nature of conservation defies the use of a “one size fits all” approach to ethical practice. There are manifold sub-disciplines which multiply depending on the criteria used to separate them. Conservators may be identified by the type of materials they work with: ceramics, glass, wood, and many others. Equally, they may be identified by the type of object with which they usually work: manuscripts, photographs, architecture, and objects (Sease 1998:100). Objects conservation, the largest and most diverse category, encompasses its own massive range of materials, types, and sizes (Sease 1998:100). Subdivisions occur along the lines of the academic discipline to which objects belong or by the function of the object, and these divisions cut across traditional material and type classifications. As a result a conservator of any given sub-discipline must understand the nature and range of treatment for any materials and techniques they may encounter in their practice (Sease 1998:100). For example, a conservator working with stone sculpture from antiquity would need to be able to understand and treat any metal, painted surfaces, or inlays which may be associated with such sculptures.

Artifact Conservation

Archaeological conservation is a unique position within the conservation profession. Archaeological conservators must fill the roles of investigator, recorder, and preserver when working with artifacts, and they are often in the best position to closely examine and analyze the material recovered from an excavation (Seeley 1987:169). These realities mean that the practice of archaeological conservation must be carried out in a different fashion than standard art or objects conservation. Current technology allows scientists to extract a wide range of information just from the dirt and residue from objects. It is now possible to determine what type of food a clay vessel held before it was buried, but an untrained objects conservator presented with a dirty clay pot might immediately clean the dirt away, thus destroying any information which could be gained from trace analysis of the soil. The kinds of evaluation and research now possible have considerably changed archaeological conservation such that cleaning, which is the most fundamental form of conservation, can destroy information about an artifact's origin or use. The archaeological conservator must carefully distinguish between the kinds of dirt which should be removed and the kinds of dirt which may be diagnostically useful and therefore should be either left in situ or retained separately for testing (Sease 1998:101). An object conservator unaware of the special requirements of archaeological conservation can easily render an artifact unusable for study by treating the object without regard to the information it may convey.

Unlike many objects conservators who focus on comparatively modern works of art, the conservator of archaeological artifacts must deal with the implications of the conservation work relative to the antiquities trade. Cleaning and conserving an archaeological artifact improves its aesthetic appeal, and thus its value, to the modern observer (Sease 1998:108). The aesthetics of a conserved object are of particular concern to art collectors and dealers. As the art value of artifacts increases, the demand for more artifacts to sell becomes greater, thus increasing the looting of archaeological sites. Conservators are in a unique position because they closely study how objects are made, their component materials, patterns of use, and evidence of repair before conservation treatment begins. Such examinations can provide substantive evidence about the authenticity of an object, whether authentication is part of the conservator's services or not (Elia 1995:249). Art dealers rely on independent verification of authenticity because art collectors are unwilling to purchase articles which might be forgeries. The conservator's confirmation that an artifact is genuine serves to enhance the article's value and marketability (Elia 1995:250).

In theory, a conservator with ethical concerns about the origin and legality of an artifact may refuse to treat an object. In practice, however, the decision is rarely so definite. All of the various codes of conduct make it clear that a conservator is expected to act in the best interest of the artifact; none provide a guide for behavior in the case of illegally obtained artifacts (Sease 1998:106). Unfortunately, this focus on the good of the object neglects to consider the impact on the wider archaeological record, and leaves the conservator in an untenable position. If the conservator refuses to treat the item in question, the looters will undoubtedly pursue treatment by another conservator who may be less discerning and possibly less skilled; many artifacts have been damaged beyond repair by inappropriate, undocumented conservation treatment (Sease 1998:109). The final factor a conservator must consider when deciding whether to treat an illegally obtained artifact is the likelihood of prosecution if their work becomes known.

The consequences a conservator faces for unethical practice are minimal. While various professional conservation organizations admonish conservators to employ best practices, the only punitive action they can take in response to inappropriate action is to rescind membership. As a regulatory function this is inadequate since membership in these organizations does not preclude professional practice, and may not even threaten a conservator’s employment. Unless the authorities become involved and the potential for fines and incarceration exists, few threats exist which might give an unethical practitioner pause when undertaking the treatment of illegal antiquities. Another difficulty is the lack of a specifically required course of training or standardized testing of knowledge which all conservators must pass. While it may be difficult, and perhaps impossible, to find an institutional position without any professional training or education (Sease 1998:110), the lack of professional standards and a regulatory body means that the quality of conservation varies wildly. Public perception of the quality of a conservator's work is not a reliable arbiter of either quality or of ethical treatment, since most members of the general community lack the education to discriminate between appropriately and inappropriately conserved items (Sease 1998:111).

The Paradigm Shifts

In the late 1960's, rapid changes occurred in American archaeology which drastically affected the conservation field. Construction boomed in the wake of World War II, threatening large numbers of archaeological sites across the country (Sullivan and Childs 2003:17). A number of laws passed in response to the loss of sites meant that, after 1966, development on federal lands required archaeological compliance work. The result was a rapid accumulation of archaeological collections (Childs 2006:205). Unfortunately, archaeologists typically preferred (and prefer) to use their limited funds to excavate as much as possible, rather than to conserve and analyze artifacts already recovered. The collections rarely received adequate care, cataloguing, and conservation; this neglect and the resulting decay of artifacts often made them unusable for research purposes (Childs 2006:205). This crisis of collections management became apparent shortly after a major paradigm shift occurred in North American archaeological theory and practice.

Early in the 20th century, archaeologists examined both excavations and the resulting artifacts through the lens of the “culture-history” theory of archaeology. These culture historians used artifacts to determine where ancient civilizations had been, what types of things those civilizations used, and the changes in certain artifact types over time. In this early perspective, artifacts are primarily useful for defining units of time and creating cultural chronologies, and artifacts lose all ability to convey information about specific people and civilizations once when they enter the archaeological record. The culture-historian did not explicitly investigate the meaning, practice, or use of the artifacts, nor what those meant to and for the society which produced them. These questions were implicit in their work, to a degree, but were not the focal point for excavations.

The accumulation of knowledge made it possible to develop new investigative questions, and in America the successor to the culture-history paradigm is known as “processualism”. The movement, a reaction against the culture-history idea, began in the late 1950’s and reached its zenith around 1980. Processualism fundamentally changed the way archaeologists used artifacts when interpreting the past. This change had far-reaching effects on the field of archaeological conservation. Processual archaeologists believe that the study of archaeology should be similar to anthropology, aiming to answer questions about past human societies based on the material culture they left behind. To this end, processualist research designs directly focus on artifacts as a means to answer various questions about human society and behavior, as opposed to the culture historian approach focused on chronologies and typologies. In its ideal form, processual archaeology is objective, valuing quantification, measurements, and statistical analyses for use in the systematic reconstruction of human behavior. These methodical ties to the sciences had a substantial influence on the field of archaeological conservation, altering the way in which conservators interact with and treat the artifacts under their care.

With the new focus on artifacts as a source of objective information came a concern for the ways in which conservation treatment altered the data available from scientific analyses of the material. The artifact became a source of objective information intrinsic to that item, and scientific testing could unlock the information so long as the nature of the object had not been changed by modern interventions. Archaeological conservation had already been guided by concern for the aesthetic and structural integrity of the object for some time, as evidenced by the attitudes of Petrie and others, who searched for treatments which could be applied and removed without changing the essential nature of a given object.

The explicit adoption of this idea of reversible treatment occurred in 1968, when the AIC released the *Murray Pease Report* and the *Code of Ethics for Conservators* together in one small volume. The principle of reversibility, as stated in the publication, required that a conservator “avoids the use of materials which may become so intractable that their future removal could endanger the physical safety of the object,” (AIC 1968:63). This section of the code of ethics had far-reaching consequences in the field of conservation when, during the succeeding decades, it became obvious that reversibility was an impossible ideal.

After the AIC published its code of ethics, laboratory documentation practices altered considerably in response to the emphasis on the importance of preparing conservation reports and keeping photographic and written records of each object treated. At the Smithsonian's National Museum of Natural History, conservators began carefully recording the individual treatments used on each artifact so that future conservators could take the artifact's conservation history into account before proceeding with additional measures. Previous records occasionally noted that treatments had been carried out, but seldom indicated the object treated or the method used (Austin et al. 2005:192, 194). Without specific documentation of the treatments applied to an object, conservation work proceeds in a vacuum, with the very real possibility that the new treatments will react negatively with the old.

The new paradigm of processual archaeology aligned well with federal laws enacted in the mid-1960s and early 1970s. The rapidly increasing number of digs allowed greater scope for scientific analyses and opportunities for archaeologists entering the field. New techniques allowed the recovery and analysis of small-scale specimens which were used to examine the relationships of humans with their environment (Sullivan and Childs 2003:19). The large number of rescue excavations led to the rise of private cultural resource management (CRM) firms, which were not sponsored by universities or other repositories willing to receive the collections after the conclusion of a project. Archaeologists of the time rarely encountered discussions about curation and conservation in the course of their education, with the result that they knew little about the requirements of proper collections care (Sullivan and Childs 2003:20).

The research designs of these archaeologists, whether they worked for a university or a private firm, focused on maximizing the amount of digging which could be done with the funding available. They also generated enormous numbers of artifacts, creating major financial and storage problems (Childs 2006:205).

In the 1970s and 1980s, it became obvious that existing collections were not receiving the level of care and attention necessary for viable research. Multiple studies on these collections found that they were degrading at an alarming rate, and few archaeologists took responsibility for the collections they had created (Childs 2006:205). Essentially, the failure to consider the final disposition of the artifacts resulted in the slow destruction of collections which had been painstakingly excavated and protected from damage in the field.

In 1991, the Archaeological Institute of America (AIA) published a short code of ethics (Archaeological Institute of America [AIA] 1991) which was followed in 1995 by the *Code of Professional Standards* (AIA 1995). These guidelines expressed a concern for the conservation of archaeological artifacts, and specify that archaeologists should make specific plans for the conservation of artifacts, setting aside funds for the work before excavation begins (AIA 1995). These measures, although they are positive moves in the right direction, are inadequate to address the damage existing collections have already sustained; they are also likely to provide only minimal protection for future collections. In response to federal standards which require the funds for collections care to be designed into the initial excavation budget, the cost of archaeological projects is increasing. Since each collection must be housed in a long-term repository, many of these institutions are becoming overcrowded, and many no longer accept new collections (Childs 2006:205).

The increased cost of archaeological work changed the way in which archaeological conservators approach objects for treatment. The ideas expressed in the original codes of ethics for conservation require that each object conserved should be given equal treatment (Sease 1998:105). This approach is fairly practical when applied to the conservation of art, since it can be difficult to decide when one work of art is more worthy of conservation than another, if both are equally in need of treatment. If the same standard is applied to archaeology, the result is that minor, highly redundant finds must be regarded as equal in importance to extremely significant items. Often, this over-conservation wastes resources on minor finds which are examined perfunctorily by an archaeologist and then relegated to storage, where they then deteriorate (Seeley 1987:169). This standard of treatment also results in astronomical budgets, quickly diminishing the number of excavations undertaken. Such a diminution then, in turn, skews the archaeological record for future researchers (Childs 2006:205).

A more practical model for conserving archaeological objects is the strategic use of preventive conservation on less significant or extremely common finds. This passive conservation approach, consisting of the complete documentation of artifacts and storage in stable environmental conditions, is beneficial to the long-term survival and investigative value of artifacts in research collections (Seeley 1987:170). Preventive conservation can be characterized by the idea that doing the minimum amount of conservation necessary to stabilize an item is the most desirable course of treatment

(Seeley 1987:170). It also allows the conservator to work in a strategic manner to maximize treatment results with the time and funding available. Culturally significant artifacts in need of conservation receive more time and attention, while minor finds are preserved for research rather than being locked in a drawer or set on a shelf to decay. The rise of minimum intervention as the gold-standard of archaeological conservation occurred in response to the realization that some historically used conservation treatments had actively damaged the objects they were intended to preserve. The problems with treatments such as cellulose nitrate, soluble nylon, and thymol began appearing in the published conservation literature beginning in the early 1980s (Appelbaum 2007:323). The principle of reversibility, created primarily in reference to the treatment of paintings, became a problematic stumbling block for archaeological conservation.

Over the course of the next decade, conservators came to realize that the ideal of reversibility was not actually achievable. The term was often used incorrectly, describing solubility, durability, and other desirable properties, rather than the fact that a treatment could be completely removed and the article returned to its original condition (Appelbaum 1987:65). Attempts to establish different standards of reversibility for various parts of a treatment were unsatisfactory (Appelbaum 1987:68). Cleaning, the first step in the conservation of most archaeological artifacts, is inherently irreversible; it cannot be subject to different standards if reversibility is the ultimate goal of the treatment. Increasingly advanced modern methods of analysis also revealed that no conservation treatment can be fully reversed (Sease 1998:104). In response to this reality, the AIC changed its code of ethics in 1994, removing all mention of reversibility from its official literature.

After reversibility fell from grace as the benchmark standard of archaeological conservation, professional practices shifted toward an emphasis on preventive conservation as the ideal goal. Preventive conservation emphasizes the importance of identifying those factors which contribute to the decay of collections rather than active treatment of the collections themselves. Once identified, adverse conditions are either corrected or reduced to levels which prevent further damage to the stored objects (Sease 1998:104). The tension between art and archaeological conservation is most visible in the idea of minimum intervention – this is most crucial with archaeological artifacts. While over-cleaning can obscure or ruin an art piece, the greatest danger for archaeological conservation lies in over-restoration. Such restoration at its root is the interpretation of an artifact without adequate evidence, and can skew future studies of the artifact and the civilization to which it belonged.

Preventive conservation not only averts the addition of new material to an artifact, it makes the most efficient use of scarce conservation funding. The sheer number of artifacts held in collections by museums and other institutions makes individual treatment for each item impossible. Preventive conservation mitigates the effects of over-conservation by keeping the small, less significant finds in decent shape until a researcher can use them effectively. The selection of significant artifacts for active treatment, and the passive storage of others in order to preserve them without individual intervention, allow money to be saved for the treatment of large or extremely rare finds. The lack of repository space cannot, however, be addressed through the use of preventive conservation. Archaeologists must begin designing their projects such that highly redundant objects do not overwhelm the repository space available (Sullivan and Childs 2003:83).

By some accounts, the idea of preventive conservation indicates a maturity in the profession of conservation: since conservators are secure that they are needed and provide valuable services, they can take action based on the best interests of the object at hand, rather than "making" work for themselves or performing treatments simply because they are able to do so (Sease 1998:104). The practice also preserves as much "potential" information as possible; it is impossible to know what analytical methods will become available in the future, and even the simplest intervention may frustrate later artifact studies.

The details of manufacture and use gleaned from an artifact can yield valuable information, but contemporary technology does not always allow this information to be gathered. Actions performed on artifacts in the past have had major implications for scientific study in present times. In 1937 and 1938, unskilled laborers under the direction of British Museum staff members extensively cleaned the Elgin Marbles using various metal tools and scrapers in order to remove surface pollution and discoloration on the stone (St. Clair 1999:418). The Elgin Marbles, which once decorated the Parthenon in Athens, Greece, are some of the most important sculpture which survives from the Classical period. The cleaning process resulted in the removal of the historical surface and the loss of some of the surface details of the sculptures. Later in the century the loss of the historical, weathered surface spawned extensive arguments about the degree of the damage to the statues and the implications for future study (Boardman 2000:233). Scholars agree that the statues were over-cleaned by modern standards, but by the standards of the time the cleaning was not only appropriate, but was even considered moderate. Similar statuary cleaned during that period shows severe damage not in evidence on the Elgin Marbles (Boardman 2000:254, 256).

This example demonstrates the importance of the idea of minimum intervention when conserving artifacts so that information which might be gained in the future is not obscured. It was impossible for early conservators practicing in the 1930s to know that science would make it possible to extract DNA from archaeological bone; it is impossible for conservators to anticipate what aspects of a given artifact will become valuable and informative at a later date. The forward progress of science and technology means that archaeological artifacts, once solely prized for their aesthetic appearance, have become intrinsically valuable because of the information – intrinsic to each object – which can be gleaned about the humans who produced and made them. When artifacts are too greatly altered by conservation later researchers cannot tell if they are studying the work of the ancients, or that of an overzealous conservator.

Digital Technology and Archaeological Conservation

As digital technology becomes more advanced and computers begin to influence most aspects of modern life, it is not surprising that multiple elements of computer and digital technology are useful to archaeological conservation. Technology is one of the ways in which science is brought to bear on the conservation problems encountered in each individual artifact. At this time, digital technology is primarily useful as a documentation tool and in the reconstruction of archaeological artifacts and sites. These uses are not, however, without their problems; the use of computer reconstruction in particular poses ethical problems which have not yet been adequately addressed. A brief examination of these problems follows; both will be discussed in detail in subsequent chapters.

Preventive conservation is predicated on the idea that artifacts receive the minimum treatment needed to keep them from degrading, and then enter a storage environment which will minimize decay. In order for this approach to be effective, each object must be thoroughly recorded before going into storage. This type of recording is an area in which digital technology excels; the use of digital technology to image and record artifacts has greatly increased the speed and versatility of photographic documentation in conservation. Digital cameras and scanners can record images more quickly and have few of the processing costs of traditional film cameras, but issues of obsolescence and the storage of image files have yet to be resolved. The positive and negative aspects of digital recording will be discussed further in the next chapter.

Perhaps as one of the consequences of the fast development of digital-virtual reality reconstructions, few current television programs about the ancient world are complete without computer recreations of archaeological sites. Computers can be used to reconstruct artifacts and buildings in order to find out more about the techniques used in their construction and the civilizations which produced them. Unfortunately, these digital creations often add details for which there is insufficient evidence, in order to create interest and a “finished” appearance which will appeal to the viewer. This practice echoes the “restorations” undertaken by craftsmen in early days of conservation. There is a great reliance on the original object, but some details must always be filled in when the object being reconstructed is incomplete.

While there are both good and bad digital reconstructions, the dilemma posed by digital re-creation becomes even more complicated due to the attitude of modern viewers towards the use of computers and mathematics to reconstruct ancient remains. A modern, western layperson lives in a social environment which conditions them to perceive the results and products of computer technology as “better” than things produced by other methods. Bad digital archaeological reconstructions give the impression to the layperson that the reconstruction is exactly correct and pristine in all details. This is sometimes the case, if the reconstruction is simply a virtual copy of the existing archaeological remains rather than a recreation of what may have been. Certain items of material culture such as exterior painted decoration, textiles, and foodstuffs are not well preserved in the archaeological record. Cultural and personal norms such as the arrangement of furniture and spaces are seldom recorded by historians. Reconstructions which show these things can never be anything more than an educated guess, at best; a computerized guess is no more accurate than that of a well educated person. A computerized reconstruction may be less accurate, in fact, because humans do not build to mathematical perfection. The computer can never account for imperfections unless it is told by its user – the same human user who is typically forgotten when a computer reconstruction appears on the television screen. Discussions of the public perception of computers and digital reconstruction follow in later chapters.

The use of digital technology to “over restore” archaeological remains can be informative to the layperson, providing a sense of the item’s context which is difficult to produce by other means. It is akin, however, to the craft-tradition of the earliest days of conservation, when artists filled in the missing areas of statues in order to make a beautiful, pristine art piece. This relationship is apparent when comparing the goals of early restoration and that of digital restoration. Initially, the restorers cleaned and rebuilt artifacts in order to show them as pristine items worthy of their art status. The process of professionalization and the scientific approach to conservation changed the goals of treatment such that treated items showed details of their manufacture and wear which reflected the usable life of artifacts. Such details allow insight into the lives of the civilization which produced the material, without the interference of modern speculation which exists when an artifact is restored without sufficient evidence.

The mode of thought evident in some digital reconstructions closely parallels that of early restorers: the goal is to display a coherent, aesthetically pleasing whole in order to make the viewing experience more meaningful to a relatively uneducated audience. Unfortunately, when the ephemeral details, such as textiles or painted decoration, of an ancient building or artifact are provided on a digital reconstruction, there is no way for the layperson to know that these details are only educated guesses. The viewer will accept what they see as an absolutely correct reconstruction, rather than one of many possible interpretations. All current conservation codes of ethics are most concerned with the idea of minimum intervention and preventive conservation rather than a full restoration of art and artifacts. Digital restoration inhabits its own “grey area”. The implications and possible misuses of digital modeling have not yet been considered thoroughly by the conservation field, but since the use of computers to interpret archaeological remains shows no signs of diminishing, these issues will have to be addressed in the near future. In particular, the effects of using a digital reconstruction when interpreting archaeological evidence for members of the public must be examined, and methods for limiting or explaining the tentative nature of these reconstructions must be enacted.

Conclusion

Conservation has evolved from a crafts-tradition into a scientific profession in which it is nearly impossible to get a job without formal education and training in the discipline. The creation of codes of ethics and guidelines for practice mark the transition from a craft to a formalized scientific profession, although the use of science entered the conservation field decades earlier. There are still some steps which must be taken in order to ensure that conservators practice their craft ethically. Since there is no enforcement or professional sanction for unethical behavior, it is difficult to stop unethical conservators from practicing. Currently, the revocation of membership to a conservation organization does not preclude professional practice as a conservator.

Technology has changed the conservation profession, particularly for archaeological conservators. It has made cleaning – the most basic element of conservation – potentially damaging to the information retrievable from the artifact, even when the artifact itself is being preserved by these actions. This reality has brought the idea of minimum intervention through the practice of preventive conservation to the forefront of professional practice. Unfortunately, codes of ethics do a poor job of covering all the ethical contingencies possible within any given course of treatment, and decisions are left to practitioners. Current codes of ethics and guidelines for practice are only partially successful in providing guidance to conservators who are trying to solve specific problems with traditional solutions (Sease 1998:98). The new avenues of documentation and reconstruction opened by advancements in digital technology will require a completely different set of ethical considerations.

Currently, the use of digital technologies in conservation is subject only to the judgment and decision of the individual practitioner – a situation normally encountered in conservation practice. The use of digital technology, however, is not yet clearly understood in relation to ethical treatment practices. The current production of digital reconstructions and over-restorations clearly employs aesthetic ideals similar to those of the early craft-restorers over more stringent scientific values. This means that the field of digital restoration must move through a maturation process, similar to that undergone by traditional conservation over the course of the 20th century, before it can be considered a scientific tool used in the interests of archaeological conservation.

CHAPTER III

DIGITAL TECHNOLOGY AND THE CONSERVATION OF ARTIFACTS: POSSIBILITIES AND PROBLEMS

The use of computer and digital technologies influences most aspects of modern western life, including the way in which the public perceives and interacts with archaeology. Television shows about the ancient world rarely lack digital recreations of the sites they discuss, and artifacts, buildings, and people are regularly reconstructed with computers (Martinez 2001:9). Movie sequences show the Sphinx and the Great Pyramid magically whole, or a Mayan temple at the height of its beauty. Dazzling images of the Roman Forum or the Forbidden City allow modern viewers to contextualize ancient remains in an accessible manner, and three-dimensional reconstructions offer impressions of an artifact that two-dimensional photographs or drawings cannot convey. Laser scanners allow the three-dimensional scanning of artifacts as small as a pin or as large as a building, and with the proper equipment the scanned objects can be printed for examination in the real world. The widespread use of computer reconstructions for the study of artifacts and sites echoes the current modern zeitgeist, in which society perceives the use of computers as "good" and, in industrial first-world nations, a necessity for living.

The omnipresent nature of computer technology in modern Western society defines social reactions to the various applications of such technology. The original notion of computers is that they are neutral tools which improve the rate and quality of human production (Marakas et al. 2000:720). The common perception of computers and results achieved with their use is not, however, unbiased. The simplest demonstration of this truth lies in the social attributes routinely ascribed to computers. The machines are often described as “thinking”, “reading”, or “hating” in a clear example of anthropomorphism (Marakas et al. 2000:720).

Computers are not only given human characteristics, but at the same time they are perceived as better than humans at performing complex tasks. A building designed with the help of a computer is perceived as less likely to collapse, and audiences believe an archaeological reconstruction designed with a computer is flawless, although the computer is a tool with which a human created the reconstruction. Humans who regularly use computers often stop questioning and checking results reached by the machine, assuming that since the computer can calculate faster and “better” than a human, its final products are without flaw (Marakas et al. 2000:721). There is little recognition that a human being is behind the computer, despite the fact that current computer technologies can only obey programming, which must be supplied by human operators. If a complex archaeological model produced in a three-dimensional reconstruction program is based on incorrect assumptions and calculations by the human, the use of a computer to render the information cannot magically negate the mistakes. Computers are also unable to supply the social information inherent in artifacts and spaces without input from humans; the reconstruction of a building which performs a particular social function – a church, for example – cannot be attained without additional context provided by a designer or narrator (Valtolina et al. 2005:1).

Unfortunately, despite the fact that computers are tools controlled by humans, the widespread assumption that they produce superior end results compared to simple human agency remains prevalent in popular culture. Indeed, when computers are not used to reconstruct and represent the function and original appearance of archaeological remnants, the reaction from audiences is subdued. The unspoken social expectation is that anything worthy of time, attention, and money will be addressed using computer technology. Conservators are not immune to this widespread cultural phenomenon, and as new uses for computer technology arise in the conservation field, the implications of such "digital conservation" are not always fully considered.

Possibilities

The most prevalent digital technology currently used in the service of archaeological conservation is the digital camera. Digital photography has many positive potential uses for conservation, particularly when used in the process of pre- and post-treatment artifact documentation. It offers a relatively fast, easy, high resolution method of visual documentation, eliminating the need for dark room facilities, the time needed for image development, and the cost of film, chemicals, and paper. With the proper combination of paper, printer, and ink, printouts of digital images can last up to 100 years with accurate color – meeting the accepted standard of longevity set by Ektachrome film (Kushel 2002:3). Digital cameras are currently able to produce images with extremely high resolutions which are largely free from film grain and noise (Griffin 2006:60). The highest resolution images can be enlarged to examine the smallest details of the photographed article, meaning that the digital picture in effect serves as a magnifying glass (Griffin 2006:60). Digital cameras are ideal for the capture of fluorescence or infrared imagery because they have a wide range of sensitivity across the light spectrum without the use of specialty films (Kushel 2002:3). Commercial demand for less-expensive high quality digital cameras constantly broadens the range of affordable options available to the conservator (Kushel 2002:3). The benefits of digital photography, and society's mainstream shift away from film cameras, have almost completely replaced traditional film photography in conservation.

Regrettably, many of the constructive uses for digital photography in conservation have a variety of negative consequences which must be considered when an artifact is subject to digital imaging. While the constant evolution of available software and hardware options offers the promise of higher quality images for less capital, the changes also mean that any given camera will likely be superseded in quality by new models in the near-term. Extremely rare or important artifacts would potentially require reimaging after new technological iterations in order to get the "best" images for study. Frequent reimaging of artifacts poses potential threats such as damage during removal from storage or display, exposure to light for photography or scanning, and contact with fluctuating environmental conditions. Once the image has been captured, offering a means to minutely examine details of manufacture and deterioration, the file must be adequately stored. Highly detailed, high resolution images result in extremely large computer files which are cumbersome to open and manipulate, occupying large amounts of disk storage space.

The file format most suitable for the long term storage of scanned images is problematic. The default format used for most users of digital cameras is the JPEG: the acronym stands for Joint Photographic Experts Group, the committee which created the standard for this type of compression file. The JPEG standard was approved in 1994 and is currently the most common format for digital photographs both in personal use and on the internet (Joint Photographic Experts Group [JPEG] 2009). JPEG files are not suited to frequently viewed or edited images because they are subject to information loss during the decompression and recompression of the file that occurs during the opening, editing, and saving process. A new, higher quality compression standard, called JPEG2000 is in the process of superseding the JPEG format, but at the current time JPEGs are not considered a stable storage format for image files. The TIFF (Tagged Image File Format) is better suited to the demands of long term storage (Kushel 2002:4), because TIFFs may be opened, edited, and saved with lossless compression. This advantage has made the TIFF the file of choice for digital image archiving (Kushel 2002:4), but while TIFF files can be stored easily, they will only survive if their storage medium survives as well. TIFF images are also quite large, and many publications and websites prefer the smaller PDF format for ease of manipulation and exchange via the internet.

While digital photography and computerized text records of conservation treatment may be faster, and to some degree, easier, than traditional documentary methods, they carry an erroneous assumption that they will take up less space over time. Contrary to the popular ideal of “paperless” society, current ethical codes for conservation state clearly that reliance on electronic records is unacceptable, due to the inherent instability of digital storage media and the mutability of information access systems. These factors make digital information extremely difficult to archive properly. For digital technologies to be minimally acceptable for AIC standards, comprehensive preservation plans for the data must be in place, two electronic copies must be kept in different locations, and the data must be monitored. For true compliance with the spirit of the guidelines for practice, hard copies of the data must be maintained as a permanent record (AIC 1994). The digitization of photo-documentation and other conservation records, if carried out to one proposed standard, results in hard copies of the information, copies on external hard drives, and copies on removable media (Kushel 2002:4). While having duplicate records is useful, particularly in the event of disaster, triplicate copies of this type will take considerably more upkeep than hard copies.

The imaging chips in digital cameras are capable of recording spectra on either end of the spectrum of visible light, including a significant portion of the infrared range not visible by the use of traditional IR film photography. The instant capture and analysis of images means that digital exposures of these ranges hold significant advantages over traditional IR film photography (Chabries et al. 2003:361). Multi-spectral imaging (MSI) records a series of images at different wavelengths outside the range of the human eye, and contains much more information than a standard photograph (Chabries et al. 2003:361). When processed through various computer programs the images show the differences in light-wave absorption by various materials;

the differences allow the computer to create contrast for the examination of artifact and document features not visible to the human eye alone (Chabries et al. 2003:364).

One of the most prominent applications of MSI in the examination of artifacts appears in the field of manuscript studies, particularly in the interpretation of texts damaged by fire or scraped for reuse as palimpsests. In ancient Western civilizations, information was generally recorded in the form of papyrus or parchment scrolls. These materials do not survive well in the archaeological record, and surviving fragments are often burned or exist under ecclesiastical writings on palimpsests. The Dead Sea Scrolls, the Scrolls of Petra, and the Herculaneum Papyri are examples of papyrus scrolls that were largely unintelligible before the advent of MSI technology. The Herculaneum Papyri presented a particular challenge. Recovered from a palatial villa which was probably owned by a wealthy Roman politician named Lucius Calpurnius Piso Caesoninus, and charred by their burial in the pyroclastic flow which engulfed the Roman town of Herculaneum, the papyri offered one of the first great challenges of scientific conservation (Seeley 1987:163). Aside from the problem of unrolling the fragile scrolls, the difficulty of reading black ink on charred papyrus frustrated scholars for centuries with their inability to recover the writings from the only surviving library of the classical period. Conventional photography failed to allow comprehensive imaging of the scrolls (Chabries et al. 2003:366), and in 1999, after a presentation on the use of MSI to decipher the Scrolls of Petra, the Italian government allowed a team of scientists from Brigham Young University’s Center for the Preservation of Ancient

Religious Texts (CPART) to begin assessment of the Herculaneum scrolls using MSI (Booras and Chabries 2001:3).

Over the course of 11 months, the CPART team imaged the unrolled fragments of the complete collection of scrolls. The Herculaneum papyri responded better to MSI than the Petra scrolls, and photographs taken through a filter at 950nm showed a sharp contrast between the papyrus and the ink. The charred remains of the papyrus were easily deciphered from the images, even without the use of computer manipulation (Booras and Chabries 2001:4). The outstanding feature of the collection is the number of works by the Epicurean philosopher Philodemus, whose writings were little known before the revelation of the Herculaneum texts (Griffin 2006:69). Lucius Calpurnius Piso was a patron of Philodemus, and the fact that most of the excavated manuscripts are his work raises interesting questions. The fact that the recovered scrolls are mostly written by one author, and the existence of other levels of the Villa of the Papyri yet to be excavated, engenders hope that a larger, more diverse library of carbonized scrolls lies preserved somewhere in the Villa and may yet be recovered and interpreted with MSI (Booras and Chabries 2001:4).

Digital CT (Computed Tomography) is a digital incarnation of a method of radiography which images specific planes of the human body and functions as a medical diagnostic tool. Traditional tomography images a plane or “slice” of the human body, either transverse or longitudinal; the technique has been in use since the early part of the 20th century (Hsieh 2003:2). A digital CT machine takes the x-ray “slices” of the body being scanned and reconstructs the scans in order to give a complete image of the internal structures (Hsieh 2003:10). A living human body is not the only object which can be imaged in a CT machine; anything alive or dead that can fit inside the gantry can be imaged (Hsieh 2003:10), and digital CT scans are often used in conservation in order to permit conservators to "look" inside an object before beginning any treatments. Currently, CT technology is such that scans can serve as an alternative to destructive investigations of artifacts.

Scans captured with a sophisticated digital CT machine allowed scientists from the Oriental Institute Museum to determine what lay beneath an Egyptian mummy's wrappings without removing or damaging the intricate decorations. The mummified remains, dating to around 800 B.C., belong to a wealthy woman named Meresamun who served as a priestess of the god Amun in the temple of Karnak at Thebes (Bonn-Muller 2009:36). Although the museum purchased the sarcophagus containing Meresamun's mummy in 1920, the spectacular decorations of the sarcophagus would be damaged by any attempt to open the coffin. A previous scan with a much slower, less accurate machine revealed a broken jaw and finger along with an unidentifiable lump in the neck and fewer pieces of jewelry than expected for a woman of such wealth and position. The scans from the new machine produced 100 cross sectional "slices" per minute, revealing the age of the mummy at death, the position of various apotropaic amulets, and the kinds of packing material used during her mummification (Bonn-Muller 2009:38). Scientists identified the lump in her neck as a mass of packing material, and found numerous unhealed fractures throughout her body, indicating that the coffin had been dropped at some point in antiquity. None of these fine details would be known without the use of the digital CT scanner; any attempt to directly examine Meresamun necessitates the destruction of her coffin decorations and her linen wrappings.

CT scans of another mummy, that of a Neolithic hunter in the Italian Alps, dramatically changed scientists' theories about the cause of his death. Discovered near the border between Austria and Italy in 1991, the "Iceman" was a middle-aged man who died around 3300 B.C. and whose body was preserved by mummification within a glacier (Gostner and Vigl 2002:323). After discovery, the mummy underwent intensive studies to determine who he was, what his life was like, and how he died. Scientists determine he had died in the spring, had eaten a meal of meat shortly before he died, and was carrying a copper axe of enormous value – a possible indicator of high social status. The exact cause of his death remained a puzzle; not until 2001, when the mummy underwent X-Ray and CT imaging at the hospital of Bolzano, did scientists discover an arrowhead buried under his left shoulder (Gostner and Vigl 2002:323). The wound from the arrow probably caused his death, but had been missed in multiple prior examinations by scientists. The use of the CT machine prevented invasive, destructive examination of both Meresamun and the Iceman. Such uses of digital technology generate significant amounts of information while following the principles of minimum intervention and preventing artifact damage during study.

Computer generated three-dimensional models offer an avenue for the reconstruction of artifacts without actual manipulation of the artifact itself. In 1901, sponge divers off the coast of a Greek island named Antikythera discovered a first-century B.C. Roman shipwreck containing a cargo of bronze and marble statuary.

Among the sculptures a unique and extraordinary artifact was recovered. Called the "Antikythera Mechanism", the geared bronze instrument survives in 82 fragments, and was initially believed to be a navigational device (Antikythera Mechanism Research Project 2009). The mechanism is extremely complex, and no known device approaches its level of sophistication until the advent of medieval clocks nearly a thousand years later. By 1975, researchers had identified more than 30 individual gears and four separate gear trains within the mechanism and believed it to be an astronomical calendar, though the understanding of its function and inscriptions remained incomplete. The artifact's extreme fragility precluded invasive studies, and many unanswered questions about the mechanism lingered.

In the autumn of 2005 a new research program centered on the Antikythera Mechanism used a hemispheric digital camera and a high-resolution x-ray tomography machine to image the device. The purpose of the project is to use digital imaging to study the object without causing damage to the artifact, and to allow researchers access to information about the Antikythera Mechanism via the internet. The digital camera used a technique known as "reflectance imaging", which captures a range of exposures with different lighting angles in such a way that subtle surface detail becomes visible, particularly after the use of image enhancement programs (Antikythera Mechanism Research Project 2009). The digital x-ray tomography used a machine developed to search for micro-cracks in turbine blades which captured images of the internal workings and inscriptions of the mechanism previously invisible to researchers. Study of these images doubled the number of inscribed characters researchers could read, and the inscriptions suggest Corinthian influences on the maker of the device (Antikythera Mechanism Research Project 2009). The calendrical functions also contradict previous theories, which held that the one of the dials represented a 76 year Callippic calendar (Edmunds and Morgan 2000:6.17). Instead, this dial corresponds with the four year cycle of the Olympiad. Other dials gave the user the ability to calculate months which excluded days in order to regulate month length, or to predict eclipses (Freeth et al. 2008:614-615). These new discoveries created a new context for the Antikythera Mechanism. Far from being merely an instrument of abstract science, it related astronomical events in relation to Greek social institutions (Edmunds et al. 2006:915), and without the use of digital imaging, it would have been impossible for humanity to completely realize the nature and importance of this artifact.

Access to information on a grand scale is, perhaps, the area of greatest progress and greatest potential for the use of digital technology in archaeological conservation. As an additional facet of their research, the Antikythera Research Project makes all of their surface capture and CT data available to the public through a dedicated website in order to encourage widespread dynamic study of the artifact (Antikythera Mechanism Research Project 2009). The information available from the website emphasizes the ways in which digital technology can advance scientific knowledge by providing researchers all over the world access to rare and precious artifacts. Without this type of information distribution, researchers would face the difficult, or even impossible, task of travelling to see each rare artifact in person and gaining the necessary permissions to conduct in-depth studies on the material.

Another method of creating three-dimensional models of significant artifacts or buildings is the use of a laser scanning system. Such a system works on the principals of elevation points used in total-station work by archaeologists. The three-dimensional scanners collect the data as a “point cloud” which is then assessed using various software programs to process range and color data (Levoy 1999:2). This system presents exciting possibilities, ranging from digital archives of the three-dimensional models, digital restoration of damaged works, high fidelity replicas, and close monitoring of artifacts and buildings (Pieraccini et al. 2001:64).

A prominent project of this type is the Digital Michelangelo Project, in which scholars from Stanford University and the University of Washington spent a year digitally scanning various sculptural and architectural works created by Michelangelo (Levoy 1999:2). The centerpiece of the research is a scanned version of Michelangelo’s David, which required a motorized gantry with horizontal arms and a movable scanner head in order to scan all parts of the sculpture adequately. Scholars expect the three-dimensional model of the David constructed from these scans to serve as the official record for diagnostic tests and conservation work performed on the sculpture (Digital Michelangelo Project 2009).

The project faced several difficulties, first among them being the extremely large file size of the finished scans. The finished scan file for the David alone takes up 32 gigabytes of file space, even after being compressed in a lossless format (Levoy 1999:3). The three-dimensional model of the David took 10 years to process and build from the data collected; the researchers estimate that it may be the largest geometric model of a scanned object in existence (The Digital Michelangelo Project 2009). The size of the finished files precludes easy viewing or distribution via removable media such as DVDs, but offers an unparalleled chance for scholars to closely study the David on a level impossible with the actual statue. Rather than viewing it from a few set viewpoints, the computer model allows viewing from any point, any angle, and with any lighting scheme. In the case of Michelangelo's large statues, which were designed for viewing from the ground, an alternate viewpoint will be instructive for art historians and conservators (Levoy 1999:3).

The scans of Michelangelo's works raise another set of concerns which must be addressed when using any kind of digital conservation tools. In light of the fact that high-quality digital scans may be used to replicate art for commercial gain, to generate images for a book, or used in digital films or programs for money-making purposes, the ownership of the intellectual property rights for such scans is a vital issue. The scans represent the artistic patrimony of the museum and the nation to which an artifact belongs. The final agreement reached between the scholars on the Michelangelo project and the Italian government stipulates that the final data may only be used for scientific purposes and may not be made available for open download on the internet (The Digital Michelangelo Project 2009). In order to acquire and use the data, researchers must prove that they have legitimate research interests and will not be using the data for commercial or private purposes; once the applicant has filled these conditions, they are granted a license to download the data from an online archive. The number of people applying for an application far exceeds the project's ability to judge the legitimacy of their application, and the solution reached by the project is to eventually turn over the licensing process to a third party management organization (The Digital Michelangelo Project 2009).

These issues illustrate the large number of factors which should be considered before undertaking digital conservation, but which are often overlooked in the excitement of using a novel technological approach to conservation strategies.

Laser scanning is extremely effective for the documentation of objects, but the technology has a range of wider possibilities. Whole buildings, building complexes, and sections of cities can be imaged – if the resources are available. CyArk, a non-profit organization whose name comes from the words “cyber” and “archive”, was created for the express purpose of serving as a digital repository for cultural heritage (Powell 2009:20). The projects sponsored by CyArk use large scale laser scanning to record archaeological sites on a grand scale and to archive the data for the sake of preservation and research (CyArk 2009). CyArk is supported by grants and multiple corporate and personal sponsors; it acts as a funding channel to reduce project costs, provide instrumentation, and raise funds from parties interested in the project at hand. The criteria for a site to be selected for scanning are simple: the site must be of global importance and must be in need of preservation (CyArk 2009).

The laser scanning equipment used for these projects can record amounts of data in a few minutes that would take years to collect manually. As of summer 2009, 26 complete projects appear on CyArk’s website, with eight still in progress. Users can view point clouds, isometric views, elevations, photographs, and reconstructions produced from the scans of sites like Pompeii, Chichén Itzá, or Mesa Verde (CyArk 2009). Issues of intellectual property similar to those encountered with the Digital Michelangelo Project appear with CyArk projects, and other sources of digital information. Few strategies exist for protecting these data from being copied and used inappropriately. Photographers who post their content online often use a strategy called "watermarking" to protect copyrighted images. Watermarking is a process by which the photographer "ghosts" their name and copyright information over the image so that others cannot easily copy or plagiarize their content. This process is useful for images, but not necessarily practical for three dimensional data. In an attempt to limit improper access and use of its scans, CyArk requires a user registration process in order to limit data access; the process includes a statement in which the user agrees not to utilize the information for any commercial benefit (CyArk 2009). In order to access the information in their database, a user must register and agree to terms of service stating that the data will not be used for commercial purposes.

Neither web-registration procedures nor the research-application solution reached for the Digital Michelangelo project addresses the question of possession of the digital artifact and the ways in which copyright will affect it over time. The standard length of time for a copyright in most countries is the lifetime of the author plus 50 – 70 years, depending on the country in question. Who is considered the "creator" of a digital work if the digital work is the scan of an existing work of art? At what point does the copyright – in the case of the Michelangelo project, held by the museum where the work is displayed – expire, and will the information enter the public domain to be used for commercial gain? These are questions which have no discernible answer at this point in time.

How to Print an Artifact

Three-dimensional printing is a process created for the rapid, inexpensive production of prototypes for various industrial uses (Cooper 2001:1). Virtual objects are fabricated directly from the computer, building consecutive layers of materials in shapes and thicknesses that result in the final object. This production by stacked layering is the guiding principle of all three-dimensional printing strategies. Stereo-lithography, the first three-dimensional printing method, used a low-powered laser to cure successive layers of UV-sensitive liquid resins which stacked to form the finished shape (Cooper 2001:3).

Other printing methods use different materials to build up the layers which form the contours of the printed object. One technique utilizes cut layers of paper, a second uses jets to spray micro-droplets of wax onto a stationary platform, while another involves spraying thin coats of epoxy into a leveled bed of gypsum-based powder (Cooper 2001:13, 27, 50). Prototypes printed from combustible materials can be used to form investment casts for lost-wax casting, or as patterns for sand casting (Cooper 2001:157). Creating casts of artifacts directly from scans allows for the creation of high fidelity copies of solid objects which are suited for this kind of reproduction. Such replicas could be displayed in art museums around the world in displays illustrating the evolution of artistic styles, or could be studied by scholars unable to access the original work. The replication of artifacts without using molding or casting techniques is particularly appealing for copying delicate objects which would be damaged by the methods needed to make an accurate mold (see below, p. 90).

When choosing a method for three-dimensional printing, a range of factors must be considered. The equipment for each method varies widely in cost and size; both funding and space determine the method of use for each conservation lab. While three-dimensional printing may be utilized in order to solve conservation problems involving the handling of fragile artifacts, the printing itself may also create conservation issues. The materials which comprise the three-dimensional printouts will have their own set of issues as they age and degrade, and a life-sized replica of an object will simply double the storage space needed in the repository.

Problems

Preservation initiatives which focus on digitizing physical objects have tremendous appeal to the conservator and to the wider public. The range of possibilities digital technology presents is dizzying. Digital scans of a given piece of art taken every few years can allow conservators to track deterioration. Replicas printed with a three-dimensional scanner can be put on display in place of fragile originals, or as temporary exhibits while the original undergoes conservation (Pieraccini et al. 2001:64). Digital scanning offers the potential to give people all over the world access to rare or unique documents – now computer users can view the chisel marks on Michelangelo's David and peruse shipbuilding treatises from centuries ago without travelling to distant museums or archives. Larger scale reconstruction efforts are equally enticing, offering internet users the opportunity to tour destinations like the Roman Forum as it appeared in the fifth century A.D. (UCLA Cultural Virtual Reality Laboratory 2003) without the necessity of purchasing a plane ticket. Cultural heritage sites lying within politically unstable countries need not remain inaccessible for years or decades, and digital tourism can potentially save fragile monuments from the immense damage associated with the numbers of tourists which visit each year. These possibilities are exciting, but also come with many problems which have yet to be adequately addressed.

One of the primary challenges with digital conservation is the storage of the data obtained. There are inherent, unsolved problems posed by digital formats, and until these are solved conservators will be unable to honor their ethical obligation to preserve information obtained by digital methods in a manner accessible to future generations. Stone tablets and paper ledgers can easily last centuries, but digital formats become obsolete and unreadable within a few years. Often, when an object is photographed or scanned, the researcher makes the casual assumption that the data will be preserved in a permanent fashion and safely passed on to future generations (Ikeuchi et al. 2007:189). This blithe confidence is false, and if the preservation of the information gained by digital conservation is not carefully considered in advance, the outcome will be negative both for the data and for the original artifact or building. The data itself does not degrade, but as the material upon which the data is stored deteriorates, the data becomes unreadable and thus unusable; many data storage forms are surprisingly fragile. The first data generated and saved in the digital revolution (Griffin 2006:64; Tristram 2002:38-39) are lost and unable to be recovered.

Saving data onto removable storage media is not a viable solution to digital storage problems; CDs and DVDs become scratched easily and may delaminate in as little as one year under poor storage conditions (Griffin 2006:64). Floppy disks malfunction when exposed to heat, dust, or magnetic fields. The bulk storage of these media forms is no less challenging than the storage and maintenance of artifacts themselves. Archive space is limited and expensive, and advanced removable storage options are not necessarily more compact than traditional forms of media storage. When converted to digital form and stored on CDs, the data stored on one six inch roll of microfilm occupies up to five feet of linear shelf space (Griffin 2006:63). The usable shelf life of a CD in archival storage conditions is estimated to be 50 to 100 years. By contrast a role of silver halide microfilm is expected to last 500 years under the same conditions (Griffin 2006:60).

The ethical obligation to preserve artifacts for future generations entails an obligation to preserve any information – digital or otherwise – obtained from those artifacts. Creating a three-dimensional scan of an artifact that is then left to deteriorate on an untreated disk in museum storage does not constitute preservation. If scans are lost in a system failure or rendered unreadable by the advance of information systems, the conservator has failed in his or her necessary duty to conserve the information.

The constant development of new information systems and technology is a fundamental problem of digital conservation. Once the problem of information storage is resolved, long term access to the information itself becomes the next hurdle. By their very nature, digital objects depend on software to interpret and display them in an intelligible manner. Unlike information recorded on stone, paper, or microfilm, digital information is in code. Without a software and hardware interface to render that code into a legible form, the data so carefully acquired and stored is useless to the conservator or researcher (Tristram 2002:38). Computer operating systems and programs are constantly changing, with updates and new versions often emerging annually or biennially to supersede earlier versions. The problem is compounded by computer technology which changes so often that most companies consider a machine obsolete within three to five years. The JPEG file which currently used in mainstream photo-imaging will soon give way to a more highly compressed format (Parulski and Rabbani 2000:103), and even the TIFF files considered suitable for long-term records will eventually be replaced. When the software or file format in question becomes outmoded and will no longer run on available machines, viewing the digital object in an authentic manner is problematic. The hard truth of the matter is that, without exception, every software program and every piece of hardware used to create digital documents and objects will become obsolete within a relatively short period of time.

Long term access to a preserved document or item and the end-user's ability to understand and manipulate it in an authentic manner is the chief goal for digital preservation. In the case of digital objects, "authenticity" means that future users are able to view and interact with the object in the same manner as the users of the original document (Doyle et al. 2009:34). Preservationists are currently using several different strategies in order to pursue this ultimate goal.

Printing

Printing to paper is a common method of last resort for the preservation of digital information. While this works well and creates a more permanent record for some digital objects like text files or photographs, it is not a viable conservation strategy for three-dimensional information: functionality and the original behavior of the object are lost in the transition (Messier and Vitale 2000:6). Printing to a three-dimensional printer is also not a truly practical strategy; the rendering produced is not the original object, so the information gained from its study is limited (see below, p. 79). It does not behave in the same way and cannot be manipulated like three-dimensional data. The production of a three-dimensional printing as a solution to data preservation exacerbates one of the problems that three-dimensional scanning is meant to solve. It creates yet another physical object in need of traditional storage and conservation, and if rendered life-size, effectively doubles the space requirement of the museum or storage repository.

Migration

The most general and widely used solution to the problem presented by technological evolution is the migration of files to new formats and programs once the current equipment becomes obsolete. In theory, migration is simple. A file is opened, converted to the new format, saved in that format, and thereafter can be opened and manipulated just as before. In practice it is not so straightforward. Migration is an iterative process, requiring intensive, repetitive human labor (Doyle et al. 2009:35) which is expensive and easily subject to error. Some information is inevitably lost during migration because the act of copying inherent to the process introduces corruption (Tristram 2002:40), and simply saving a file in a new format cannot guarantee the authenticity of the preserved digital object. In fact, it is highly likely that the new program will omit or change aspects of the digital record in question. Some changes may be as simple as different pagination in a text file, but application files for obsolete software may look and act completely differently once migrated (Tristram 2002:40).

Encapsulation

Encapsulation is the one solution which completely preserves a digital object in its original format. The process "encapsulates" the files in a digital "wrapper" which consists of instructions for decoding the information in the future. The wrappers contain directions, in both human-readable text and digital code, on how to interpret the file, including how to create the tools necessary to read the file (Tristram 2002:41). This technique shows promise, but is a complex process unsuited to handling the sheer number of hardware iterations and software updates released each year. It also requires that programs be encapsulated or converted with specific forethought, and conservators have no way of knowing what information will be valuable in the future; encapsulation will likely be a viable solution for text files, but not for programs created with more complex applications (Tristram 2002:41).

Emulation

The most realistic approach to preserving a digital object's authentic content, behavior, and appearance is a process known as emulation (Doyle et al. 2009:35). Emulation relies on a program created to mimic the registers and behaviors of older hardware. The obsolete software runs on a newer machine through the buffer of the emulator program, thus keeping the original data intact (Tristram 2002:40). This method is not without problems. Emulation is not the true preservation of the original environment, but merely an imitation. Programs and objects run by an emulator are recognizable, but do not behave or respond in the same way as they did on the hardware for which they were designed. For example, figures often appear warped, or the sound is not accurate (Tristram 2002:41). Of the available current approaches to digital preservation, emulation most closely approaches the goal of authentic access, but it is by no means an ideal solution.

Cost of Digitization

A second difficulty with digital conservation is the great cost involved with digital objects, due primarily to the fact that the active conservation required for the data has no time limit. A box of papers in acid-free folders and boxes, stored properly in a climate controlled archive can be expected to last years, perhaps decades, with only periodic inspection before needing to be re-conserved. The cost to produce a digital image is relatively low; storage and longevity concerns coupled with the need for active conservation increase the cost exponentially. The most generous estimates of data format longevity barely make it past a single decade, and data "shelved" for that amount of time is data lost.

The varied nature of digital technology and the nearly infinite number of ways in which it may be utilized in conservation makes a complete examination of financial matters impossible. The sustainability of cost and budget will vary depending on each project, and changes in equipment cost and staff salaries also preclude the production of any standardized model for cost estimates. It is, however, possible to examine some of the general developments and fiscal implications of digital technology in conservation without expounding upon the nuances of each individual situation. The greatest employment of digitization as a method of conservation occurs in the preservation of manuscripts and other paper archival materials. The costs of digitizing paper materials afford a rough indication of the overall cost of digital preservation in comparison to conventional methods, and are valuable in evaluating a few of the situations encountered during a digitization initiative.

Scanning or photographing artifacts for digital preservation may at first appear to be a cost-effective alternative to conventional conservation treatment. For example, digital photography can potentially lower documentation costs by eliminating the need for film, processing chemicals, and paper; there is no denying the appeal of a method which could reduce or eliminate the need for a large physical storage space. The cost of digital SLR cameras has declined precipitously in the past few years, allowing the arrangement of a high quality documentation system for a relatively small financial investment. Once again, however, the problem of long-term digital storage comes to the fore when choosing a file format for image storage. The manipulation of captured images using photo editing software can degrade the quality of JPEG files due to the decompression and recompression which takes place when the file is opened, altered, and saved. TIFF files tend to be large, taking time to open and manipulate, and occupying a great deal of server space. In order to be considered permanent records, digital photographs must be printed in hard copy for archiving and storage. Paper and printer combinations currently allow the printing of digital photographs which are expected to last as long as those printed with conventional darkroom techniques (Kushel 2002:3), but the prints themselves take up the same amount of space as conventional photographs.

The price of equipment is often the primary consideration in the planning stages of a digitization project but contrary to this preoccupation, capital investment is not the greatest financial outlay inherent to digital conservation. In the published accounts of digitization initiatives undertaken in libraries and archives, staff costs comprised anywhere from 32% to 94% of the total cost (Puglia 1999; Cook 2000; Phillips 2005). In a study conducted during a digitization project at the University of Michigan conservative estimates for the staffing costs amounted to 27 cents for each page digitized; such costs make the goal of digitizing entire libraries an exceptionally expensive proposition (Bonn 1998). All estimates and figures published for these types of projects include only the cost for the completion of the initial digitization plan – none account for the long-term staff costs associated with storage and active conservation of the resulting files, though the costs certainly must be absorbed by the institution at some point in time (Puglia 1999). If the institution has its own storage facilities, passive hard-record storage is likely to be less expensive than digital archiving due to the open-ended time requirements of digital information. Until and unless stable, static software and file formats are developed, it will never be possible to simply store data passively without risking its loss.

Some institutions constrained by space or personnel limitations elect to transfer their archival functions, both digital and hard-copy, to third party service providers. The fee schedule for the storage of both hard copy records and digital files varies immensely depending on the provider (Chapman 2004).. A comparison of fee schedules from the Texas State Library and Archives Commission (TSLAC) and the Online Computer Library Center (OCLC) demonstrates the differences in cost for digital and hard copy files. Both institutions are non-profit, and offer their services to a specific clientele. TSLAC serves Texas state agencies, and OCLC serves various libraries across the United States (Chapman 2004). The current fee for hard copy storage provided by the TSLAC archives is $2.25 per cubic foot per year for paper records and 51 cents per roll of microfilm per year (Texas State Archives and Library Commission [TSLAC] 2009). OCLC provides digital storage on a sliding scale depending on the number of gigabytes (GB) stored, ranging from $750 per 100GB per year if fewer than 500GB are stored, to $300 per 100GB per year if more than 10 terabytes (TB) are stored (Online Computer Library Center [OCLC] 2009). The OCLC rates for digital storage are much less expensive than the hard copy storage of TSLAC, but the nature of digital information means that the cost of storage is mutable, and will be subject to alteration in order to preserve the data over time.

Payment for digital archiving secures only the storage of the data; the services offered do not extend to migrating, printing, or otherwise dealing with the information as software and hardware formats change. The customer institution will have to pay fees for space on the server, but in order to meet the conservation standard for digital files set by the AIC, a hard copy of the records must also be maintained. It is entirely possible that, in order to meet proper conservation standards for the digital file produce by scanning an artifact, the conserving institution may find itself obligated to pay for both types of storage for an indeterminate period. Unlike paper records and artifacts, which typically require storage and minimal conservation, an institution must provide funds not only for data storage but also for active conservation of that data *ad infinitum* (Griffin 2006:64).

There are no plans outlined in any case study for conserving the data in the event of institutional failure and the subsequent loss of funding from that source. The fact that museums, universities, and archives are not perpetual is absent from the consciousness of these authors. The same problem appears when projects use funding from special partnerships or special funds: once the funds are depleted or withdrawn, the funding for conservation must be drawn from another source if the venture is to continue (Weintraub and Wisner 2008:16; Phillips 2005). These deficiencies eloquently accentuate the limited time frame imagined by most conservators when planning digitization initiatives – no published projects have adequately addressed the manner of data preservation on a truly long-term scale.

Selecting Artifacts for Digitization

The problem of high cost raises the third dilemma inherent to the process of digital conservation: how are artifacts selected for conservation using digital technology? The switch to digital cameras for photography is relatively simple and inexpensive, and the benefits gained in image quality and the elimination of processing costs and equipment justify the transition; not all issues are so easily addressed. Many museums and repositories face problems generated by limited financial resources. Leaving aside the question of long-term storage and maintenance, such institutions may be unable to muster the personnel or equipment funds necessary to image each item in their collection. In that case it becomes necessary to choose which artifacts will be imaged using advanced digital technologies and which will not. For example, if only a given percentage of a collection can be laser-scanned with the funds available, many artifacts will be left out. Unless digitization is carried out in wholesale fashion, the decision regarding which artifacts are imaged becomes a matter of determining “worth”. Selective judgments regarding historical worth can never be objective – they are completely dependent on the values and opinions of the person holding the power of final selection (Friedell 2008:5, 7). The conservation of an object, even digitally, validates its worth as an important thing, and by this process conserved objects become more important than those which are not conserved (Clavir 2002:35).

Many museums display great enthusiasm for digitization as a means for increasing public access to their collections via the internet (Roy et al. 2007:315). Digital files offer a means of bringing together widely scattered research materials in order to form a coherent comparison of the original objects or texts (Smith 1999:8); they also offer an unprecedented tool for teachers, who can use the files to punctuate their lessons with images of objects their students may never see in person. Some major museums are digitizing selected portions of their collections in order to complement reference collections already in existence (Thompson 2002:7). Currently the process is biased towards paper documents rather than other types of cultural records and remains, since manuscripts and books are the types of artifacts most easily imaged, shared, and viewed via computer screen.

In terms of conservation, digital files offer the possibility of reducing wear and tear on fragile original documents, since researchers can examine the files on a computer. If the scanned images of documents are extremely high resolution, the viewers can study the nuances of each page more closely than they might be able to do in person. But no matter the benefits offered by such myriad possibilities, there are still problems inherent with this sort of access to research surrogates, particularly when the audience is the layperson instead of the research scholar.

The most commonly cited criterion for the digitization of a given artifact or art object is the permanent, global significance and value of the artifact in question (Ayris 1998). In the case of archaeological artifacts this generally means that articles of great value or in an excellent state of preservation stand in the forefront of a digitization initiative, a situation which may be dangerous for the perceptions it fosters in the public. Patrons observe archaeological artifacts in museums and form their own opinions and value judgments based on what they see. Museums generally take pains to present ordinary, everyday objects in their exhibitions along with the great treasures of a civilization in order to present a balanced representation of the culture to the viewing audience. There is no way to ensure that visitors will read all of the information presented in an exhibit, but the act of walking through a museum necessitates the viewing of more than one item, ensuring at least a minimal level of contextual perception by the guest. Although digital exhibitions facilitate the distribution of contextual information, items can often only be viewed one at a time, and there is no way to ensure that a patron sitting at a computer workstation looks at each image individually.

Emphasizing the best and brightest of artifacts in digital exhibitions and libraries echoes the prevalent attitudes of the early days of archaeology, in which the "treasures" were extracted from excavations and the common pot sherds were tossed in the rubbish heap. It distorts the audience's perception of archaeology, archaeological artifacts, and the powers of the conservator. If only precious or well-preserved artifacts appear on a computer screen, the viewer knows that these objects are "important", and so must have a great deal more to communicate about the culture they represent than broken sherds of pots or bits of bone. In reality, the sherds and bone likely convey more information about the day-to-day activities of ancient peoples than any items of precious metals or a single pristine artifact. It also implies that archaeological artifacts are universally recovered in a good state of preservation, or that conservators will be able to make even the most damaged and degraded objects into showpieces for exhibition. For these reasons the choice of artifacts for digitization must be carefully considered and the implications of the process must be clearly understood before any digital initiative begins.

Conclusion

Digital technology offers a wide array of possibilities for use in the conservation of archaeological artifacts. The greatest use so far has been in the area of document scanning and photography, providing a means to create high quality documentary images and to reduce wear and tear on fragile documents. Digital photography using specific filters allows the use of multi-spectral imaging to view objects in ways which are not possible with the naked eye, and permitting great advances in manuscript studies and papyrology. Advances in digital CT technology over the last decade let American researchers digitally unwrap an Egyptian mummy, and permitted European scientists to locate the arrow which killed a Neolithic man, both without ever penetrating the corpses. Laser scanning offers another fast, accurate method of documentation for cultural heritage, particularly for large-scale or architectural remains, and when used in conjunction with three-dimensional printing opens the way for the production of high-fidelity replicas which can be used for display, study, or commercial sale.

These digital technologies do not, however, replace other areas of conservation and are accompanied by their own set of difficulties and ethical problems. When using digital forms of documentation, conservators must reconcile the desire to use advanced digital technologies in the service of conservation to the ethical obligation to make records permanent and accessible. Questions about the ownership of intellectual property in the long term, the rights of artistic patrimony, and the manipulation or copying of files for commercial use are not adequately addressed by currently copyright laws. If digital files are to be stored perpetually, these questions must be considered before the digitization process commences.

This imperative runs counter to current social perceptions, in which computers pose the best solution for problems of archiving, reproduction, and reconstruction. The selection of a fraction of available artifacts for digitization is laden with potential repercussions because it involves making value judgments about the artifacts chosen for display. The display of an artifact in a museum inherently removes the artifact from its context, but the array of objects in an exhibition provides a sense of the culture from which the items came. The artifacts shown in a digital exhibition are completely removed from all context, potentially giving the audience an incorrect view of the culture, of archaeology, and of conservation.

The most intractable difficulty surrounding the conservation of digital information is that even the most modern solutions to the problem are finite. Without exception the current programs and applications used to resuscitate digital objects will become obsolete, generally within five years, and need their own solution in turn. Conservators can expect that, with proper conservation and storage, an object of paper or stone may last hundreds of years. Many non-digital texts and artifacts can also be passively stored, meaning that so long as the proper storage conditions are maintained, and items are checked periodically, the collection can be expected to last. Digital objects require constant, active conservation, energy, and thought, with all of the associated costs, *ad infinitum* (Tristram 2002:39; Griffin 2006:64). Some estimates of the long-term cost for data storage and conservation are 100 times greater than the corresponding costs for microfilm and paper (Griffin 2006:64).

These objects are, in essence, new artifacts in and of themselves, and they are artifacts created within an inherently unstable medium. So while digital technology offers exciting possibilities for the documentation and conservation of archaeological artifacts, the conservator must be cognizant of the fact that by using these technologies they will be creating at least as many new conservation problems as they solve.

CHAPTER IV

MUSEUMS, REPLICAS, AND THE PUBLIC

Digital technology offers a host of ways to produce high-fidelity replicas of archaeological artifacts and remains, allowing larger audiences a certain degree of access to unique cultural history. The extremely high quality of these copies, however, raises questions about the use of such duplicates and their effect they have on the public. Replicas have indisputable value in museum settings, since they can be touched and manipulated, but they are also relevant for situations that do not include physical touch. Historically, replicas of artifacts have been used to foster a greater understanding of the construction techniques and technology available to ancient cultures, and to better illustrate the broad sweep of history to the lay-public. The manner in which the public responds to these replicas demonstrates the possibilities and limitations inherent in their use, and emphasizes the potential difficulties which confront museums as they expand the use of digital replicas and reconstructions in their exhibits.

Replicas and the Intrinsic Value of the Original

In 1892, Norwegian shipwrights created a replica of the Gokstad ship, a 9th century Viking war ship excavated from beneath a burial mound in 1880 (Nepstad 2003). Christened the *Raven*, and later renamed by the American press the *Viking*, the ship sailed across the Atlantic Ocean and the Great Lakes in order to appear at the opening of the World's Columbian Exposition (known as the Chicago World's Fair) of

1893. After the close of the fair, the ship navigated the Mississippi River to New Orleans, returning to Chicago before being temporarily stored in the Field museum (Nepstad 2003). Restored in 1919, the ship rested in an open shelter in Chicago's Lincoln Park until the 1970s, exposed to the weather and left without any preventive conservation. The ship currently rests in Good Templar Park, which is closed to visitors for much of the year, and conservation groups are struggling to find the funds to stabilize and conserve the vessel. The amount of damage sustained over its decades of exposure can only be mitigated by an intensive conservation effort costing millions of dollars (Nepstad 2003). By contrast, the Gokstadt ship lies in a wing of the Viking Ship Museum in Oslo, Norway, drawing thousands of visitors each year.

The *Viking* failed to capture the public imagination at the time of its arrival in America because the Chicago World's Fair celebrated the "discovery" of the new world by Columbus; the replica of a Viking warship served as an unwelcome reminder that Viking explorers may have reached the new world centuries earlier. The *Viking* demonstrated the seaworthiness of the Gokstad ship's design and sailed through waters the original ship could never have reached, yet it sits neglected and unseen while its progenitor, a national treasure of Norway, is preserved in a museum. Funding for public museums and the conservation of the artifacts they contain is one way in which the public expresses how much it values a given artifact or set of remains (Swade 2003:273). The dilapidated state of the *Viking* speaks volumes.

The reason for the ship's neglect lies in the fact that "original" artifacts have an intrinsic value and authenticity which replicas do not possess. Humans have complicated relationships with objects which are often independent of the physical makeup of the item (Swade 2003:273). The value is based on the object's history. For instance, if a famous person owned or used the item, if it was acquired by a family member, or if it is mentioned in an archive, it has more value than an identical item with no provenance (Swade 2003:273). Unlike the field of fine art, which may confer art value upon reproductions due to the processes used to create a copy (Beerkens 2009), the questions of verisimilitude and reproduction are less relevant for artifact replication. No matter how good a reproduction is, and no matter how authentic the materials and processes used for its creation, it does not – and cannot – have the history unique to the artifact. Replicas are "object surrogates", which manifest only the physical dimensions of the original relic. While they may be useful for taking measurements or for experimentation, they do not contain trace evidence which may provide information if they are subjected to the proper forensic tests (Swade 2003:274). Facsimiles also do not have the symbolic attachments and historical "presence" which make an artifact worthy of regard and study. While digital technologies offer unprecedented opportunities to produce copies of great works of art, or of archaeological remains, a digital copy of an item, no matter how indistinguishable it is from the article itself, can never be the "real" thing (Greenberg 2004:42).

Replicas can, and have, occasionally become important artifacts in their own right, particularly if they outlast the original subject (Barassi 2007). Such is the case for the Diskobolos and the Doryphoros, two Classical Greek bronzes which are known and studied only through various surviving Roman copies of the original sculptures. Each copy has its own unique history and is valuable as an artifact of antiquity, in spite of the fact that it is a replica. Unfortunately, the public perception of the *Viking* as merely the copy of the real thing is static. The perception that the ship is “just” a copy has led to its current dilapidation, and does not take into account the fact that the ship has now become an artifact in its own right. The *Viking* undertook voyages the original Gokstad vessel could not have. The ship’s design was proven seaworthy by the *Viking*’s voyage, meaning that the Gokstad ship might have been able to negotiate the trans-Atlantic voyage (Nepstad 2003), but the replica went through the Erie Canal and later sailed down the Mississippi River, a feat the Gokstad ship certainly never performed.

Creating Context

The Museo della Civiltà Romana (Museum of Roman Civilization) uses replicas in conjunction with an array of models and select artifacts in order to illustrate Roman history. The visitor to the museum has a choice of three different thematic courses through 60 rooms housing the collections (Rossi 1991:7). The first track provides an historical perspective, beginning with the origins of Rome and moving through the Christian period. The second path, organized by theme, contains items relating to the everyday lives of Roman citizens, organized into categories such as school, living spaces, and libraries. The final section is a huge scale model of the city in the time of Constantine the Second which allows modern viewers to make visual and mental spatial connections between various locations in the ancient city.

In the environment of the Museum of Roman Civilization, replicas are used to great effect as teaching tools (Rossi 1991:7-8). One of the centerpieces of the collection is a plaster cast of the relief carvings on Trajan's Column, most of which are not visible to viewers on the ground when they visit the monument. Other pieces in the collection are reproductions of artifacts which are scattered throughout museums in Rome and across Europe, or which were destroyed in World War II (Rossi 1991:7). Archaeological objects in isolation can provide only limited understanding of the culture which produced them; it is the social and archaeological contexts which give the material meaning (Dallas 2007:33). It is possible for experts to acquire this meaning in the course of their studies, but such contextual knowledge is not a societal norm. Seeing the sculpture, tools, and other artifacts relevant to specific aspects of daily life in context with each other allows the audience in the Museum of Roman Civilization to form a more coherent understanding of Roman culture. Without the use of replicas, the thematic assemblages in the museum would be composed of whichever artifacts the museum owned or could borrow, and the final result would undoubtedly be less articulate. As a result the replicas, though they lack the intrinsic value of original artifacts, have a greater educational value than objects exhibited without complementary material providing context for the viewer.

One of the greatest tools for educating the public about the past is the interactive exhibit. Modern museum visitors do not wish simply to observe the remains of the past, they want to touch and move the objects in order to see how they function (Dallas 2007:40; MacDonald and Alsford 1989:42). The preference for interactivity in the exhibit can be met by producing replicas which, unlike original artifacts, are specifically designed to be touched and moved without worry about degeneration or damage. The Da Vinci Experience, an exhibit at the San Diego Air and Space Museum (SDASM), uses replicas of Leonardo da Vinci's drawings coupled with reproductions of the experimental creations to allow visitors to control and manipulate functional models of Leonardo's work (San Diego Air and Space Museum [SDASM] 2009). Each machine is accompanied with a copy of the corresponding design drawing, allowing participants to see how Leonardo envisioned his creations on paper and to then to execute the intended function in the physical world. In this case, the object surrogates make up the entire exhibition, yet they create both a kinesthetic and mental experiences for visitors, which allow them to connect with the past in a manner which cannot be achieved by viewing an artifact in a glass case.

Real vs. Replica

Replicas can be produced in order to protect the integrity of an original artifact when display is deemed too damaging for a fragile relic. One of the only Roman equestrian statues to have survived from antiquity stood at the heart of the Piazza del Campidoglio in Rome for centuries. The greater than life-sized gilded bronze sculpture depicts the emperor Marcus Aurelius mounted on a horse with his hand outstretched. During the medieval period, most bronze statues of pre-Christian emperors were destroyed by the church; the statue of Marcus Aurelius survived only because it had been misidentified as a sculpture depicting the emperor Constantine. Originally positioned near the Lateran, the sculpture was moved to the piazza in 1538 where it remained until a bomb attack in 1979 prompted a thorough examination to evaluate its condition and repair the damage (Vaccaro 1992:109). During this study, conservators discovered that the bronze was severely deteriorated due to atmospheric pollution, and the overall condition required immediate mitigation (Vaccaro 1992:109). The subsequent cleaning and restoration took eight years, and the original statue now rests in a specially constructed exedra in the nearby Palazzo dei Conservatori Museum.

The final placement of the statue caused controversy in Rome between people who want the original to remain in its place and those who wish to protect it from further damage. The sculpture's gilding cannot survive extensive exposure to the pollution and humidity of Rome, and other sites in Italy have removed vulnerable sculpture and put reproductions on display. A replica of the David stands in Florence, and the bronze horses of Venice are displayed in the Cathedral museum while modern replicas decorate the façade of St. Mark's. Many Romans, however, feel that continuing to replace statues and art with replicas will lead to a city that is false (Haberman 1990), and it is certainly true that not every statue can be protected and replaced by a copy. The replica which now stands in the square was created in 1997, the first year of preparation for the Roman Catholic Church's Great Jubilee of 2000. In the intervening years between the original sculpture's removal and the erection of the replica, the pedestal which had supported the statue for more than four centuries stood conspicuously empty. While the replica has a different patina than the gilded bronze sculpture, it serves to fill the empty plinth at the heart of the piazza while ensuring that the actual bronze suffers no further damage from exposure to pollution and other hazards. The object surrogate serves both as protection for the original object and as an aesthetic stand-in at the center of Piazza del Campidoglio.

As the statue of Marcus Aurelius demonstrates, there is a compelling argument for the use of replicas to proactively shield authentic material from damage. The use of object surrogates becomes problematic, however, when the original object is no longer accessible to the public and/or researchers. The statue of Marcus Aurelius remains directly viewable by the public in a museum accessible from the Piazza in which it once stood. This is not the case for all artifacts. The question of access to original material, and stewardship over the material, must be carefully considered before digital replicas begin making widespread appearances in museums worldwide.

In 1905, the Smithsonian Institution became the first museum in the world to mount a dinosaur fossil in a lifelike pose (Smithsonian Institution 2001). The remains of several *Triceratops* had been recovered in Wyoming in 1891 by John Bell Hatcher, but none of the specimens was complete. Even today, no entirely intact *Triceratops* specimen has ever been recovered. In order to complete the mount, museum staff used bones from more than a dozen individual dinosaurs to piece together a visually coherent specimen (Griswold 2002). The natural result of this jigsaw puzzle approach was a specimen with disproportionate body parts. Intact rear limbs of *Triceratops* had not yet been found; the rear feet, installed because they were approximately the right size, belonged to a duck-billed dinosaur (Griswold 2002). The head was 15% too small for the body, one humerus was longer than the other, and the front legs were mounted in a sprawling position, giving the fossil a slouched appearance (Stokstad 2001: 1483).

The horned lizard remained on display in the National Museum of Natural History (NMNH) for 93 years, and was one of the museum's most popular exhibits. A conservator's examination in 1998 revealed that the fossil was in dangerously poor condition and needed immediate intervention. Some of the bones had cracks and others were riddled with pyrite disease, which breaks up fossils from the inside out (Smithsonian Institution 2001). Restoration and conservation on the bones commenced immediately, and took more than three years to complete. Unlike earlier restoration work on fossils, the conservation of the Smithsonian *Triceratops* (later dubbed "Hatcher" to honor the man who recovered the bones) used state of the art digital technology which produced a final exhibit unlike any previously seen in the museum. A paleontologist on the NMNH staff proposed creating a digital replica of the skeleton, which could be studied and manipulated in order to make a new mount without the size and symmetry errors of the original (Griswold 2002); this proposal was adopted, and the journey towards a virtual *Triceratops* began.

The scientists considered both laser scanning and digital CT as methods for capturing their data, but laser scanning proved to be the most viable solution because most CT scanners could not handle the sheer size of some of the bones (Griswold 2002). Once the three-dimensional scanners captured the data, scientists used the measurements to correct the sizing and symmetry deficiencies of the *Triceratops* through computer manipulation. In the digital dinosaur, scans of other *Triceratops* fossils – re-sized appropriately for the new mount – or mirrored scans of the existing bones filled in the missing parts of the skeleton. Scans of known *Triceratops* foot bones replaced the duck-billed dinosaur fossils, which had been part of the mount for nearly a century.

A stereo-lithography machine printed some of these files, creating three dimensional copies of the fossils. Casts of the printouts produced fiberglass and plaster "fossils" for display (Wilson 2006:53). The 600 pound skull presented problems during the scanning process because it was too fragile to be removed from its supporting armature (Moltenbrey 2001:28). Researchers ultimately scanned the head several times in order to properly capture the data. The file size for the skull, resized to match the rest of the display, was so large that it had to be reduced from 30 million data points to 1.5 million points in order to be printed – the larger file size made it impossible for the printer's computers to process the data (Moltenbrey 2001:29). The resizing caused the loss of some of the fine detail of the skull; some areas were abnormally smooth, while others actually took on a pixilated appearance in the final printed version. Museum personnel manually smoothed down surface areas and added missing surface texture to the printed object with silicone and plaster before mounting the replica skull (Wilson 2006:54).

In addition to the replica bones for the mount, researchers produced a fully rendered digital model of the skeleton. Scientists used this virtual model to study the joint articulations, take detailed measurements, and analyze the shape and function of the bones (Smithsonian Institution 2001). The museum also created a 1/6- scale model from the digital files, and this model proved invaluable to researchers since, unlike the enormous fossil bones, it is easy to move and position for examination (Perkins 2000:302). A bronze skull cast from the scale model is included in the final exhibit (Smithsonian Institution 2001). The analyses of the model ultimately revealed that Hatcher's original orientation was incorrect, and that the new mount should have its feet in a more upright position (Griswold 2002); Hatcher's current posture reflects these findings.

In order to convey the importance of this innovative research method, the Smithsonian included the details of the scanning and conservation process in the new exhibit created for Hatcher. The newly mounted Hatcher stands in the Dinosaur Hall, facing the museum's Tyrannosaurus Rex (Smithsonian Institution 2001). It is accompanied by the scale model. Museum goers see a video detailing the entire conservation process, including a digital animation of the *Triceratops* in motion, more accurate than any other version of dinosaur movement since it is based on anatomy rather than artistic interpretation or conjecture (Smithsonian Institution 2001). Further reflecting the project's importance, both to the museum and as a step forward in the use of digital technology in museum conservation, a full-size bronze statue of Hatcher's skull – cast from the digitally produced model – now rests in front of the NMNH, acting as a symbol of the institution (Kernan 2001:35).

While paleontologists studied the data from the fossil scans, the fossils themselves underwent conservation to mitigate the pyrite disease which threatened to destroy them. Conservators filled the cracks with special hardeners designed to strengthen the fossils and to encapsulate the pyrite disease. They also produced padded jackets for each bone which hold the fossils in a stress-free position (Smithsonian Institution 2001). The original skull and humeri remain on display, and the rest of the bones reside permanently in the Smithsonian's collection (Smithsonian Institution 2001; Perkins 2000:300).

There is one troubling side effect of the conservation and digital technology used to such effect when re-mounting Hatcher: some of the original bones are now locked away in the museum's collections, accessible only to staff and researchers. As already seen with the *Viking*, the public is often less enthusiastic about viewing replica objects than seeing the "real" thing. Unlike the statue of Marcus Aurelius, the authentic fossils are not on display nearby so that patrons can see the difference between the fossils themselves and the casts on display. Even if the display clearly details which fossils are authentic and which are replicas, the overall impression given by the exhibit is one of a "real" fossil skeleton. Using replicas in place of real artifacts and restricting access to such material is an ethical quandary with no easy resolution (see below, p. 91).

A second quandary raised by the re-mount is the issue of cost. The conservation and production costs for the digital model and printed replica of Hatcher totaled more than a million dollars (Stokstad 2001). Had the museum used a more traditional and less expensive conservation method, these funds could have been used for the conservation of numerous other artifacts, rather than being focused on just one skeleton. Hatcher is, however, one of the most popular exhibits in the museum, drawing crowds and revenue for the Smithsonian. No doubt the money making potential of the exhibit was one factor in the decision to use advanced technology to conserve Hatcher and produce the new mount; the process was only the first step in a planned $100 million renovation of Dinosaur Hall (Stokstad 2001; Griswold 2002). These decisions highlight the difficulties encountered when artifacts must be selectively conserved – in this case, the more significant fossil received conservation care, but the results may allow other, smaller finds to receive better preventive conservation at a later time using the funds raised by the popular exhibit.

Museums and the Tide of Public Opinion

The conservation and presentation of artifacts in museums can skew the modern communal perception of the past. Any art museum with classical stone sculpture on display provides numerous examples. The monuments stand in their galleries, the pure white stone of the carving evoking the austerity and elegance often associated with ancient Greece and Rome. Unfortunately, the state of these figures does not accurately reflect their appearance when they stood in their original context. Contrary to the modern archetype of white marble sculpture, stone sculptures in ancient times were brightly painted in order for their details to be easily visible. The stone statues of antiquity emerged from the first archaeological excavations mostly stripped of color, time and exposure having weathered away the pigments from their surface. Restorers ignored the remaining traces, or even removed them during cleaning (Ebbinghaus 2007:2). Most artists of the time, emulating what they believed to be the ancient style, left their own stone sculpture bare and the neo-Classical movement they inspired defined the modern viewer’s paradigm of ancient sculptural art (Gurewitsch 2008:68).

Modern analysis of ancient statuary under ultraviolet light and in conjunction with raking light photography now allows conservators to gather concrete evidence of painted colors and patterns once present on certain ancient stone figures (Ebbinghaus 2007:1). Vinzenz Brinkmann, a German archaeologist, has undertaken the task of challenging the long accepted paradigm for ancient art (Gurewitsch 2008:68). Three-dimensional scanning plays a crucial role in presenting his findings to the public by allowing the creation of high-fidelity plaster copies of statues. Each ancient sculpture is scanned, and a three-dimensional copy then forms the basis for a mold. The resulting plaster copies, painted to mimic the patterns and pigments found on the ancient figures, allow the modern viewer to reconsider previously held assumptions about ancient art.

The advent of digital scanning and printing technologies made the creation of these copies possible, and even simple in relation to earlier copying techniques. Traditional methods of copying statuary involve plaster casts of the original, which would damage any remaining traces of ancient color; other methods of copying are time consuming, less exact, and expensive (Gurewitsch 2008:71). The painted copies, exhibited in museums and galleries around the world, surprise and disconcert their audiences at first, but generally receive positive receptions (Gurewitsch 2008:69). Digitally created copies are helping to change the prevailing misconceptions about ancient sculpture, but the presentation of bare stone statues continues to influence modern thought: most television shows and movies depicting ancient Greece or Rome still portray homes and streets decorated with white marble statuary. The lesson learned by the example of ancient statuary is clear: the public often believes that which they are shown by authoritative individuals, and once public opinion is set, it can be changed only with great effort.

Their specific educational training and the existence of a demonstrable conservation methodology transforms conservators into authority figures in the eyes of the public. This is particularly true in a museum setting, because the information presented in most museum exhibitions derives from scholarly research (Dean 1997:218). Since the lay-public does not have concrete knowledge of the details of every artifact, the audience must trust that the conservator has remained true to the nature of the objects on display. It is possible, and undesirable, for the conservator to produce replicas which are re-interpretations of the original, particularly when the replica is produced from a deteriorated artifact, and appears to be in “better” condition than the original (Barassi 2007). The same situation occurs when digital reconstructions include too many details, independent of evidence, making people believe that archaeology can tell more about the past than is actually possible. In many cases, conservators provide the opportunity for the public to understand an artifact or work of art, and when over-interpretation or over-conservation occur, the final product on display is the conservator’s creation rather than the original artifact (Talley 1996:8).

A touring exhibit arranged around Lucy, the 3.2 million year old fossilized skeleton of an *Australopithecus*, brought some of the issues surrounding the use of replica exhibits into focus. Arranged in 2008 by the Houston Museum of Natural History, the exhibit aimed to expose Americans to Lucy while raising funds to promote paleontology in Ethiopia. Many prominent scientists protested the exhibit, claiming that the skeleton was too fragile to travel (Gibbons 2006:574). The seven-year planned duration of the exhibit also raised concerns that the length of the exhibition would hinder the study of the remains. They would be unavailable to researchers in Ethiopia, where the fossil was found and is stored, for the duration of the tour (Gibbons 2006:574; Dorfman 2007). Both the Smithsonian and the Cleveland Museum declined to exhibit the fossil, citing its fragility and global importance as concerns (Gibbons 2006:575; Kennett 2007). Many museums worldwide possess plaster casts of Lucy's bones, but these do not draw the huge numbers of visitors who traveled to see the originals on display. In some cases, the public even feels deceived when they realize that an artifact they are viewing is a replica (Barassi 2007).

In response to criticism of the choice to exhibit Lucy, one scientist vocalized the problem inherent to using replicas: "You can make the same intellectual point with replicas, but I don't think you can make the same emotional point. The original fossils have a presence that casts just don't have," (Dorfman 2007). This point has failed to carry weight with critics of the exhibition. Although concerns about the fragility of the specimen are legitimate, the worrying trend in this case is the apparent belief among scientists that the public has very little "right" to see real artifacts – in this case, fossilized remains – and should be content with viewing a plaster copy. Before the exhibition, access to the original fossil was restricted to scientists: the authentic Lucy has never been displayed in Ethiopia, her home country.

The Problem of Replicas

The question of whether to display a replica in lieu of an authentic artifact has no truly satisfactory answer. Museums are institutions which exist to contribute both to the intellectual development of the public and to the advance of scholarly knowledge. The tension between the needs of scientific researchers and the obligation to show the public "real" objects can be negotiated, but never eliminated. The same question spills over into the matter of digital replicas, whether they have been printed off or simply exist as an electronic file visible through the filter of software and screen. If an artifact is conserved and a digitally created reproduction is displayed, to whom does the "right" to view the original artifact really belong? The distinction between "scholar" and "interested lay-person" must be made when access to an artifact is restricted, and the decision reflects on the values and practices of the institution itself. Restrictions meant to keep access equal can easily be misinterpreted or skewed by personal politics if rigorous standards are not enforced, and any such occurrence will undoubtedly result in a skewed body of scholarly knowledge being passed on to future scholars; if researchers do not have access to all available sources, their work must inevitably contain gaps.

Although some of the original bones which comprise Hatcher's skeleton remain on display in the NMNH, most of the "real" parts of Hatcher are located in the Smithsonian's vaults because they are too fragile to withstand the rigors of exhibition. The funds used for the conservation of the fossils and the resulting digitally created replica come from public sources – the same public that is no longer allowed access to the original fossils – as the Smithsonian is funded by tax dollars through the American government. The files created by scanning the fossils can easily be shared by email (Smithsonian Institution 2001), but unlike the researches for the Digital Michelangelo project, the museum has not shared the conditions which must be met by researchers who desires access to the *Triceratops* data. The institution has neglected to outline how the data can be accessed and has not dictated what can be done with the data – whether it may be used for commercial purposes, or whether it can be altered and manipulated in the course of artistic pursuits. Access to most of the data from the Antikythera Research Project is easily obtained via their website, but users must acknowledge that the copyright belongs to the project, and agree not to use the data for profit-making pursuits (Antikythera Mechanism Research Project 2009). If the data from Hatcher is made available at some point in the future, perhaps for a television show featuring dinosaurs, it will become necessary for the Smithsonian to establish guidelines and terms of use. The financial implications of the data's use will be particularly important, since capital raised by licensing the scans of Hatcher could potentially fund conservation efforts for other objects in the museum.

Digital replication techniques can be used to produce high-fidelity replicas for display, but the primary consideration when producing such a replica must be the point at which the well being of an artifact outweighs the benefit obtained from displaying an authentic object. Only at that point is it ethical to produce and display a replica, particularly if the artifact itself is extremely important. Well known artifacts can draw large numbers of visitors to a museum, and the visitors who come to see a specific item will likely have to travel through other parts of the collections in order to access the featured exhibit. The famous artifact can also increase audience receptivity, paving the way for the communication of ideas via other objects in the museum's collections (Dean 1997:220). The same opportunities will not be present when replicas are displayed, since object surrogates resonate on a different level with their audiences than do original materials.

Challenges with Digital Reconstructions and Re-creations

Museums often use interactive virtual displays to satisfy audiences with a strong desire to experience exhibits on a multi-sensory level. The patron can use various controls to manipulate and examine artifacts in a computer environment, but digital objects are limited by the manner in which they must be viewed. Unless a given item is printed out, the data must be interpreted by computer software and displayed on or projected onto a screen. The medium presents several problems in terms of interactivity, with the most serious being the lack of a material item to touch or view. The second is the difficulty involved in establishing an understandable physical scale so that the user can properly contextualize the size of the artifact represented by the digital image (Rountree et al. 2002:133) The electronic file displaying Hatcher's skull is readily viewable, but the skull of a *Triceratops* does not make the same impression on a computer screen that it makes in person; its real size and volume cannot be adequately displayed. It is difficult to communicate the proper scale of a digitally rendered artifact in such a way that the lay-public can connect the item they see on the screen with the actual relic. Failing to do so means that the audience loses all sense of the object being "real" (Rountree et al. 2002:133). On a standard-size computer screen, a six foot tall dinosaur skull may appear to be only inches high, and a small coin can easily appear to be the size of a saucer.

Digital object surrogates are inherently problematic so long as they exist only as data. The pixels which represent a scanned artifact are not bound in the computer environment by the same physical and chemical laws which govern objects in the real world (Swade 2003:274). Computerized reconstructions can allow a machine to work despite the fact that it could not work in real life (Swade 2003:276). Some of Leonardo da Vinci's creations lacked the power or construction material necessary to make them functional, yet many people see these same creations, magically functional and operating, as a screen saver on their own computer. There is no protection against tampering, and no way for an observer to know whether the object on their screen has been manipulated or not, since the display does not distinguish between edited and original material. For example, text files do not retain evidence of revision and editing, eliminating any clues to the author's thought processes, and a photograph can be altered to make an ordinary person look like a supermodel. Three dimensional objects rendered as computer data are no different, on their basic level, than these examples.

Digital reconstructions also have extreme limitations when it comes to historical research. They can be used to study form and function, but they cannot function as evidentiary sources for chemical analysis, metallurgy, or palynology. The homogeneity and lack of natural laws present in the computer environment mean that objects with moving parts will function as they "ought" to function, rather than how they actually did function (Swade 2003:278). All glitches and quirks of the original machinery will be smoothed out in the digital environment, robbing the reconstruction of some of the true aspects of the authentic item. In short, the virtual artifact represents the logical concept or "idea" of the artifact rather than the reality of the object itself.

Over-restoration with digital technology actually does archaeology – and the public – a great disservice. Computer reconstructions are trendy and popular. They abound on television and in movies, helping the public visualize the past without need for extensive study and education. In shows about the Roman Empire, the Colosseum of Rome often grows miraculously whole, complete with statues, carvings, and screaming crowds. Unfortunately, such reconstructions are not presented for what they are: cinematic "best guesses" founded on the scholastic research of fallible human beings. In general, the narrators do not explain how the creators based the reconstruction on historical sources and the archaeological evidence, and that the evidence for certain structures is sketchy or poorly understood. The overall effect is similar to that of a true crime show causing people to believe that entire criminal scenarios can be constructed from just one hair, complete with motive and supporting evidence.

When a television show broadcasts the image of a Roman basilica growing from the most rudimentary foundation ruins into a gloriously intact structure complete with surface decoration, sculpture, and ephemerae the public assumes that all of these details must be completely accurate. This is partially due to the trust engendered by scholarly research, and the assumption that scholars have control over the final appearance of the reconstruction, but most of this trust is precipitated by the attitude of modern society towards computers. People trust computer-created reconstructions, even reconstructions used in an entertainment setting, to be accurate simply because computers were used to generate them. Using computers to excessively restore ancient remains on a computer screen creates misconceptions about the past, rather than clarifying and teaching about the history of human civilization. Perpetuating untruths about archaeology and directly undermining the educational goals of conservation is an unacceptable result for this type of digital conservation. Such reconstructions should be clearly prefaced and displayed in a manner which encourages critical thinking and which makes clear that these images are not perfect, since there is no way for archaeology to provide every detail of an artifact or structure.

Conclusion

The museum-going public has a special relationship with the artifacts displayed in exhibition settings. They ascribe value to these artifacts based on various emotional criteria, which do not generally apply to replicas. Replicas lack the emotional and social contexts which make the artifact important for study, and which draw audiences to see them in exhibits. Although replicas are often displayed as a protective measure for a fragile original article, displaying a copy in place of a “real” item should only be undertaken after careful consideration. The emotional impact on the public of displaying a replica must be balanced against the wellbeing of the original artifact. High-fidelity replicas do, however, have exceptional value in educational settings. Functional copies prove that archaeological artifacts functioned in particular ways, some of which are contrary to researchers’ expectations. They also form the basis for interactive exhibitions, providing kinesthetic experiences which are impossible to achieve with actual artifacts, since the artifacts might be damaged if subjected to frequent handling. Reproductions and casts of artifacts are also particularly useful for creating context in museums when the artifacts which are most informative reside in assorted other museums worldwide. Various replicas create a coherent contextual exhibit, and help museums to utilize collections to best advantage for educational purposes.

Digital technologies provide a plethora of opportunities to create replicas, both in the real world and in cyberspace. Laser scanners can capture minute details on complex artifacts, sending them to a three dimensional printer for manifestation into a concrete object. The information also exists as data, able to be accessed around the globe through email or web registration. Computer reconstructions of buildings and artifacts allow audiences to fully visualize the material as it once appeared, even if only a trace of the original remains. These digital wonders are not without their disadvantages, however.

Digital items which are not rendered into concrete form must be viewed through interpretive equipment, sometimes limiting the perspective of the artifact to the size of the viewing screen available. Such a viewing experience can make the communication of a proper scale challenging. The computer environment allows artifacts to be manipulated without detection by the audience, and objects can be made to behave in ways impossible in nature. Digital replicas also cannot be physically or chemically analyzed for information about the artifact’s use and past. The final disadvantage is that viewers, in general, believe information when it is presented by authoritative sources. In current society there are few sources more authoritative than computer generation programs, and reconstructions of ancient remains are routinely over-restored by adding details for which there is not definitive evidence. The majority of viewers will perceive a computer reconstruction, even an inaccurate one, as correct.

Unfortunately, these methods of digital restoration and reproduction can be used without enough consideration of their effects on the public and upon the emotional connection between audiences and original artifacts. In the future, more care should be taken to educate the public about the sources used for digital reconstruction and about the reasons for displaying a replica in place of an original relic. Such a course of public education on behalf of museums would help allay the public's unquestioning belief in digital reconstructions, and may help audiences better understand the contextual and education value of replicas in museum settings.

CHAPTER V

SUMMARY AND CONCLUSIONS

While the roots of the conservation tradition go back hundreds of years, it was the late-19th and early- 20th centuries which saw the primary evolution of the profession into a science with a demonstrable method and formal course of education and training. Beginning with Rathgen and the Berlin Museum, the conservator has become the primary custodian of cultural artifacts in museums, working against decay and the loss of information. Archaeological conservation arose out of the fields of fine art and architectural conservation, but the requirements for this type of conservation are significantly different than those of its progenitors.

The creation of codes of ethics and guidelines for practice mark the formalization of the conservation profession, but as yet no ethical principles guide the practice of archaeological conservation. Digital technologies offer promising methods for preserving archaeological remains, but have not been subjected to rigorous ethical examination by conservation's professional organizations. The result is the use of digital reconstructions and conservation methods according to the judgment of individual conservators; often these uses focus on creating a coherent aesthetic whole, harking back to the actions of the early craft-restorers as they pursued a pleasing aesthetic product rather than the most scientifically informative result. The new forms of digital technology have significant issues which must be considered in order for digital conservation to mature into a worthy tool for ethical practice.

The forms of digital conservation currently in widespread use center on document scanning and the photographic documentation of artifacts. In particular, digital photography and MSI have proven themselves to be highly useful when deciphering information which is not visible to the human eye. Other types of digital imaging and scanning promise to become more important as the technology improves; even now, some objects have been imaged to a very high degree of accuracy, and the nature of the digital objects is such that the information can be made widely available to researchers in order to foster a varied spectrum of inquiry into the nature and meaning of the artifacts.

Conservators must walk a fine line between the use of exciting new technologies and the ethical obligation to make records permanent and easily accessible. Digital file formats and the hardware required to view them become obsolete very quickly, requiring expensive active conservation in perpetuity. Such conservation is exceptionally costly, and most repositories have little funding to spare. Digital files created from scans or photos of archaeological artifacts are effectively new artifacts in and of themselves, created within an intrinsically unstable medium. These files, designed to aid conservators in the long-term preservation of artifacts, create new conservation problems which currently have no solutions.

One of the most exciting aspects of digital imaging and three dimensional scanning is the creation of high-fidelity replicas of archaeological objects for study and display. Museums may be tempted to use these methods and to display the resulting reproductions without adequate consideration of the long-term disposition of data and the emotional impact on the public. Audiences respond to object surrogates differently than to authentic items, because the replicas lack the social context which gives artifacts their value. This does not mean that replicas are ineffective; they have immense value in creating educational context for an audience, for the protection of artifacts from decay or damage, and for facilitating kinesthetic connections in hands-on displays of functioning reproductions. The needs of the original artifact also retain primacy; displaying a replica is better than allowing the original to deteriorate to the point that nothing remains to display or study.

Modern Western society often revolves around the use of computers, with the result that computer generated reconstructions commonly appear in popular culture. This includes digital reconstructions on television as well as in museum exhibits. Often, audiences believe that computers produce better end results than humans, despite the fact that a computer is always a human-controlled tool. Audiences tend to believe information when it is presented to them in an convincing manner by an authoritative source; in the current age, the use of a computer to create a reconstruction gives the final product authority. Unfortunately, digital reconstructions of ancient material – particularly those appearing on television or in the movies – are routinely over-restored, and are not displayed as the cinematic conjectures they are. The historical and archaeological sources for the reconstruction are seldom elucidated, and the lay-public lacks the knowledge base to understand that what they are seeing is not necessarily the way a building or object actually appeared in the past.

In the future, the guidelines for ethical conservation practice should include more information about the exact constitution of ethical practice. Codes of ethics should specifically address the need for a stable digital archive medium, and should stress that conservators should not create digital "artifacts" without first considering the long-term preservation of the resulting data files. In addition, both conservators and archaeologists should insist that digital reconstructions of ancient material remains are properly acknowledged as "possible" reconstructions, rather than definitive ones. Television programs and museums should scrupulously disclose the various sources used for each reconstruction, both archaeological and textual, and must avoid the temptation to over-restore digital creations in pursuit of an aesthetically pleasing final product. Conservators and archaeologists must be cognizant of the fact that the use of digital reconstructions in popular culture shapes the public's perceptions of these professions. In the same way that 17th century restorations of ancient sculpture continue to distort modern perception, the failure to maintain a high standard of accuracy and disclosure during the digital reconstruction of archaeological remains will result in misperceptions of the past which will be difficult – if not impossible – to change.

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