



## Research Article

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# Supplements to the Study of African Works of Art

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### Abstract

*For many years, the history of the arts, crafts and connoisseurship has been determined using the sensory organs; with the introduction of technology, researches in the sciences have found their ways into the study of humanities and the arts. There exists recently additional modern, genuine and acceptable ways of assessing art historical studies other than the traditional sensory means - sight and touch. There is the need for art historical studies now to be more advanced, viewed from a global standard. Apart from formal, iconographic and iconological analyses, art historical studies of the 21st century attends to other pressing evidence and developments with the use of hi-tech and the embrace of scientific approach to studying works of art. Qualitative and evaluative modes of research have been employed for this discourse; it concludes with recommendations to research institutes and African governments to show interest in material compositional information of African art objects for their scientific and historical significance.*

**Keywords:** Art history, art authentication, provenance, compositional information

## 1. Introduction

The exploration of material compositional information in Africa art historical studies has received little attention, the convention has been situated more on formal analysis, iconography and ethnographic contexts of African works of art; little attention is given to medium information and technological probes (Olaleye-Otunla, 2020b). Ignoring what actually is the nature of a material in a work of art amounted to rupturing the genetic relationship between the process of creation that created work of art and the material use for it with its all identifiable constituents. The exact nature of a particular material is much relevant today in art historical studies when considering what actually is in an art work (Olaleye-Otunla, 2020b). For consideration, such questions as to where exactly could the source of the materials used for a work of art be? How was such a work of art produced? What material things lend itself to such creativity? Can such material(s) be identified and differentiated from other material(s) that are sourced from the same origin; is it possible to identify such a material with another? The conviction that an art historical study is not complete today without material and compositional information buttressed the facts (Olaleye-Otunla, 2020b). The possibility with the exploration of the use of X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF) and techniques to gain access into material compositional information of works of art as it is being done in other parts of the world begs the question. Vansina (1984: viii) remark that works of art must

be helped, not by imagination, but by the retrieval at as full an historical setting can uncover for their understanding.

All over the world, there are institutions catering for works of art; the Museum is one of such that embraces all aspects of study – art inclusive. What an artist produce ends up in private collections, galleries and museums. Museums, art collectors and gallery owners today need to know why it is important to do material analyses for provenance studies of objects in their collection and any other object about to be collected. This initiative however could militate against some problems encountered in art world to-day. According to Olaleye-Otunla (2020b), major problems encountered in the art industry are art forgery, misidentification, fakes, theft, vandalization, fraud, jurisprudence, and genuine art historical analysis which has been dated back to the Renaissance period.

When there are known cases of art misidentification, fakes, forgery, theft, vandalization, fraud, art jurisprudence, and so on, compositional analyses of works of art is necessitated. Vansina (1984:3) posits that the job of art history is to answer queries about the authenticity, place and time of production of an object; identify the creator-artist; all manners of fabrication, considering the style, meaning the socio-cultural context under which the production processes existed and what other idiosyncrasies observed about the object in comparison to others around it looking at every conditions, circumstances and quality of its creation both internal and external. African art scholars have neglected more the material compositional information; the true origin of many museum objects cannot be determined. Looking at the sophistication and attention given to use of wood and metal in African art historical study today, the same have not been extended to terracotta and ceramic works of art. The Nok terracotta and ceramic sculptures-the oldest known in Africa, for instance, were dated between 700-500 B.C, but their material analyses were not yet carried out to determine the origin of their parent material despite the dating ascribed to them. According to Vansina (1984:24) the convention in African art historical studies is cursory (visual) inspection which is desired to be enough, but not, the description should say something about the medium of an object which only laboratory analysis can give details.

## 2. Literature Review

Selected papers on procedures in material compositional analyses in art historical studies were perused for this body of research. At present, there is dearth of studies that focuses on material composition analysis on art works in Africa. Material analysis is part of verification of the source or origin, trade and exchange which reveal information about the movements of people that have benefitted from the works of art. Reynolds (2008) observes that art historical community and academic art historians have distant themselves from the art market making it difficult for art provenance to still remain outside the discipline. The resources for art provenance research in African countries are lacking, the only resources available are that of Asia, Europe or North America where methodologically material compositional analysis had become part of provenance investigation. Arnold *et al.* (1991 & 1999) had clearly demonstrated that provenance researchers were correct in their assumption that compositional analysis (finger print) could link manufactured pottery and their corresponding material services together. According to Olaleye-Otunla (2020b), the analytical disciplines are revolutionised with the use of precise and sensitive tools for art scholarship and investigation: technically, the development of analytical equipment for the understanding of material analysis had been of great advantage in provenance studies in the recent times.

Various studies in the highly industrialised world have analysed series of works of art in terms of their material composition for art historical studies. Among others, Bagley (1987) investigates long-term studies of Chinese bronzes; Harper and Meyers (1981) investigates Sasanian Silver. Other studies alongside these ones have demonstrated the relevance and usefulness of doing provenance examination with stylistic studies. Reedy and Meyers (1987) investigates Himalayan bronzes where it was established that technical studies has proved to be useful in identifying probable region of manufacture.

Fehrenbach (2010:1) reports the effective use of technologies for studying various artifact classes in Southeast Asia; Miksic and Yap (1990, 1992); Stork *et al.* (2009); Ardika and Bellwood (1991) have also published chemical compositional studies of earthenware ceramics from Southeast Asia. Pryce (2008); White and Hamilton (2009); White and Pigott (1996) mentioned this approach has been developed in studies of origins, craft economies, and production systems for bronze metallurgy while Bellina (2003) recognises that of stone, glass beads and ornaments. Vincent (2000) identified that, earthenware ceramics represents a potentially abundant source of technological data but have so far been underrepresented. Evidently, some museum laboratories have also developed programs of technical examination with stylistic art historical studies to determine provenance of objects in their custody. A good example is Stone's (1982) report of Renaissance bronzes carried-out at Metropolitan Museum.

### 3. Examples of Material Compositional Studies in African Art Studies

Some notable material studies that are of Yoruba, Southwestern Nigerian origin are listed below: Underwood (1949) *Bronzes of West Africa*; Fagg and Underwood (1949) examination of the so-called Olokun head from Ife; Moss (1949) Further light on the 'Olokun' head of Ife; Willett (1959) Bronze figures from Ita Yemoo, Ife, Nigeria; Willett (1964) Spectrographic analysis of Nigerian bronzes; Barker (1965) Ife Bronze Heads; Willett (1967) *Ife in the History of West African Sculpture*; Shaw (1970) *Igbo Ukwu Bronzes*; Werner (1970) *Metallurgische Untersuchungen der Benin-Bronzen des Museums für Volkunde Berlin*; Williams (1974) *Icon and Image*; Werner and Willett (1975) The composition of bronzes from Ife and Benin; Willett (1976) True or False? The false dichotomy; Willett and Fleming (1976) A catalogue of important Nigerian copper-alloy castings dated by thermoluminescence. Others include Goucher *et al.* (1978) Lead Isotope Analyses and Possible Metal Sources for Nigerian "Bronzes"; Craddock and Picton (1986) medieval copper alloy production and West African bronze analyses; Olabanji *et al.* (1990) correlated elemental patterns derived from Esie statues with that obtained from surrounding rock types using results obtained from PIXE and XRF probes; Craddock *et al.* (1986) look at Copper to Africa: Evidence for the international trade in metal with Africa. Joel *et al.* (1995) Stable lead isotope characterisation of various copper alloys used in West Africa: an interim report; Craddock *et al.* (1997) Metal Sources and the bronzes from Igbo-Ukwu, Nigeria; Ige *et al.* (1998) investigated the composition analysis and use of soapstone.

Recently there are, Willett (2004) *The Art of Ife: A Descriptive Catalogue and Database*; Willett and Sayre (2006) Lead isotopes in West African copper alloys; Ige & Swanson (2008) provenance studies of Esie sculptural soapstone from southwestern Nigeria used JEOL JXA 8600 Super probe to know the mineral composition of the statues; and Ige, Ogunfolakan & Ajayi (2009) also explored the use of ICP-MS in the analysis and chemical characterization of some potsherd pavements from parts (Yorubaland) of southwestern Nigeria; Drewal and Schildkrout (2010) *Kingdom of Ife*; Platte (2010) *Bronze Head from Ife*; Olalye-Otunla (2020a) *Inventoring Ita Yemoo Museum, Ile-Ife: Yoruba Pottery Collection, Ile-Ife*; Olalye-Otunla (2020b) *Yoruba Pottery Objects: Material Compositional Studies*.

### 4. Inherent Problems in previous African Art Historical Studies

Vansina (1984:19) report that when African art objects first arrived in Europe around 1470 they were regarded as curios. As the knowledge of African art historical studies deepens, valuation for works of art from south of Saharan Africa increased. At the arrival of the 18th century, works of art from Africa had been acquired by European museums as specimens for material culture. For example, the Benin punitive expedition by the British soldiers in 1897 and that of the discoveries of Ife heads gave rise to the realization that there are great artworks in Africa. Around 1905, African art appreciation experience wide acceptance to the extent that European Avant-garde artists of the 20<sup>th</sup> Century adopted the richness of forms exhibited in African arts. As at that point, African artistic rendering of forms were the major concerns. According to Lewis (1990:231-232), to the dismay of African arts,

social contexts, meaning and material compositional information were out of focus in African arts studies.

By the 1950s, African art had been considered part of anthropological studies but the historical studies of African works of art were not under consideration at all. The early 1950s witnessed the archeologists' consideration of the significance of African art studies and they opened up the historical studies of African art. By the 1990s there was an intervention by anthropologists the likes of Adrian Gerbrands (1917-1997)<sup>1</sup> who address the missing link between African arts and its historical studies. African art studies thus grew up to a point before its tide was crippled by art mercantile which eventually stifled the development of art historical and provenience studies of African works of art.

The store houses, archives museums and private collections had served as repositories for thousands of artworks from Africa for many years. Resultantly, some African works of art were secured from destruction, theft and vandalism. Ideally, in any repository or a museum set up, works of art / objects acquired are assigned dates they are collected, place or origin where they are sourced and many other relevant data requirements that are considered prerequisites to storage are recorded specifically because large numbers of works will eventually be involved as long as acquisition and storage continues. Such a record present reliable bases for a sound framework for art historical studies and they set canons for fixing other undocumented works from the field. Such a systematic referencing of such works in terms of their possible dating, description of the iconographic details, and especially how such works are related to each other is relevant to the cataloguing system. Sadly, the high valued attached to African antiquities and works of art encouraged illegal excavation, forgeries on a large scale, trade origins were kept secret; most publications on African art objects were also influenced by art dealers to boost their trade so much that the provenience of African art objects remained questionable. These and others are problems associated with the collection of African works of art.

The lucrative art market in south of Saharan Africa gives room for fakes and forgeries of works of art. Illicit African art vendors with the collusion of their European cohorts practice these businesses. It has been noted that with the illicit business works of art offered for sale do not actually conform to their acclaimed origin and the speculated dates assigned to works of art. Regrettably too, experiences have shown that some curators and owners of works of art come into the art market with falsified art historical information about such works. Therefore, to expose fake, forgery, and material examination of objects or works of art need to be carried out through forensic and specialised laboratory tests and analyses. In south of Saharan Africa, the description of, as well as the provenance and provenience studies of works of art remained elusive without which dating, material compositional analysis can be relevant. Art historians in Africa have not given attention to all these due to lack of fund, facilities, expertise, as well as institutional will-power to execute such provenance and provenience research. To make the work of provenance more difficult, most names of past African artists were not known, even up till today, only works like paintings and sculptures are given little attention, worst is the case of ceramics and pottery collections which abounds all over Africa.

The description of works of art without accompanied material compositional information constitutes a rupture in the genetic and immanent stages of formal analyses in aesthetic considerations. Defining contextual analysis of an object calls for its corresponding material compositional information which determines an incontrovertible registration mark such works of art could attain which is far more than mere cursory observation and recognition. Laboratory analysis often spelt-out further details of the raw materials and technology involved in the creation, linkages and influences surrounding works of art.

When provenance, provenience and material analysis are determined, the work of identification and documentation of works of art is said to be comprehensive. These however could have the

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<sup>1</sup>Adrian Gerbrands a museum curator (1947-1966) and professor of cultural anthropology (1966-1987) at Leiden University.

addition of other evidences aided by photographs and other digital information for a holistic exercise. As much as all these are in place, then the chronology of works of art (absolute or relative) can be set about a particular collection. Works of art with many techniques of production with several dating are now recognized all over the world. Any proper chorology of related of works of art thus can be set against each other with oral, written and laboratory examinations, without which the art history will be inconclusive. All these could therefore be summed up into what is referred to as Art authentication, a necessary imperative in art industry.

## 5. Art Authentication

The Oxford English Dictionary explains that Authenticity, sometimes is “as being in accordance with fact, as being true in substance”, or as what it professes in origin or authorship, as being genuine”. The Webster’s New 20<sup>th</sup> Century Dictionary also says that authentication is to prove that something is “actually coming from the alleged source or origin.” The need for art authentication started shortly after the Renaissance when demand for works of art were on the increase and more, works of deceased artists also became more relevant. By the turn of the 14<sup>th</sup> century, there were increased interest in material acquisition, several things were brought-in from distant nations, and notable among such were works of artists; this resultantly contributed to the increased monumental value of works of art across the globe. The awareness thus created then generated an upsurge in value, and acquisition of art objects which resultantly extends to the contemporary times.

In history, the identities of some artists were not so much of value especially during the Classical and Renaissance periods because art was meant to serve religious, aesthetic ends and historical references. Patrons of the arts especially painting, sculpture and architecture knew the artists as well as their products. Usually, then, artists were known to have apprentices who understudied master-artists and they were expected to use their master’s techniques to produce works as a service and payment for their apprenticeship. Works of art produced in a similitude of any of the masters techniques were most times erroneously attributed to such art masters, such works are considered not as forgeries though, but somehow were not regarded as the masters’ original.

Art authentication seeks to know the connoisseurship, historical, curatorial, legal, ethical, theft and every analytical dimension that surrounds any work of art. The ever developing art industry today is multi-disciplinary, various initiatives with special skills in training, facilities, policing and prosecution of practices are required. Many experts are now recognised in the art storage and management; such includes art historians, criminologist, law enforcement agents, analytical chemists, forensic experts, conservationists, legal authorities, prosecutors, and so on.

The effect of art frauds on art industry, individual artists and the possibility of generating art authentication theory and practice is burdensome; the practical approaches to understanding analytical investigation and legal prosecution of art frauds in authentication practices is also tasking. Resultantly, authentication practices portends an interdisciplinary initiative between art, science, museums and legal institution in the area of cultural, antiquity materials, conservation and management with many implications for litigators, court of law, police, government, museums, art historians, and so on. When authentication is carried out about a work of art there is the likelihood of reduction in the attempt to steal or pilfer such; eventually this will discourage every sharp practice that may come up in art sales; and this even boosts art trade when genuine works of art are paraded for auction or sale. Regrettably, the trend of art forgery has not abated because works of art has been projected as items of commerce with high monetary value so much that the names of artist became so much tangential to works of art production. When the demand for works of art began to exceed supply and many artists came up stage marks and signatures were given to artworks for identification. Irrespective of that, fraudulent artists still come on stage to falsify works of popular artist because of increase in worth of the works of such famous artists.

From the foregoing, the thrusts of art authentication therefore is, having a clear understanding of what an original work of art entails from an art historical as well as the legal point of views. For

instance, in art litigations, authentication is a prerequisite to the admission of evidence, that is, showing that the evidence in question is what its proponent claims. Litigators need to understand how artwork is authenticated because of the basal evidence required by the court of law based on a particular context and content. At some point in history famous artists were known to have created art forgeries too, the case of Michelangelo in 1496 is noted (Jones *et al.*, 1990 and Rubinstein, 1986). In many nations around the world, Art forgery attracts criminal prosecutions even though it used to be a difficult thing because of so much evidentiary burden involved. Art crime has assumed important dimension to the extent that Association for Research into Crimes against Art (ARCA) has been organized and the body itself has instituted a Postgraduate Certificate Program in Art Crime and Cultural Heritage Protection dedicated to the study of art crime in 2009 (Vuong *et al.*, 2018). The burden of proof so demanded by art authentication thus stemmed from provenance and provenience determination needed, especially for art historical studies of African works of art.

## 6. Guide to Doing Art Provenance for Art Historical Studies

An object or antiquity may therefore have both a provenance (i.e. where it was found) and a provenience (where it has been since it was found). This connotes that provenance be requesting for facts about activities that predates being documented into any record, as well as other facts that has something to do with its history after it has been rediscovery. What then is art provenance? Reynolds (2008) observes Art provenance is an area (of art) that has long been ignored by the art history community and academic art historians; it is only recently that art historians have started given consideration to art provenance. Art provenance research is all about finding out who has benefitted from a work of art, both aesthetically or financially. Yeide (2001) observes also that the pursuit of art provenance research should be geared towards identifying the owner(s) and the movement of an object from the time of its creation to where it is being located as the time of investigation. Why then is art provenance necessary for art historical studies? What is to be done? How should it be done? All these questions constitute important areas which an art historical scholar seeks to answer with particularity African works of art.

What is provenance? According to Oxford English Dictionary, provenance is an English word which is derived from French word "*provenir*" meaning "to come from" by implication, this is asking after the time and events surrounding the existence of, who owns, place and people who have kept any historical object. This word have been originally and mostly used in gathering attributes about works of art, but today has wide range of applications in the fields of archaeology, botany, paleontology, archives, manuscripts, printed books, food and beverages, science and computing. The primary purpose of provenance study therefore has been to provide contextual background and the circumstantial facts for the original production or discovering of a work of art and to establish as much as possible any written information about it, the sequence of previous ownerships, who actually kept such work of art, the possible and plausible storage places such has rested will eventually help in authentication. There are several comparative technique expert opinions and scientific tests which in addition could be used to establish comprehensive provenance documentation of an object's history.

The American Association of Museums' (AAMGPR, 2005) Guide to Provenance Research gives an ordinary meaning of provenance as "origin". i.e where do things come from? Reynolds (2008) posits that, the origin of a piece of art makes a significant difference in its value. Soanes (2004) gives three related definitions of art provenance: (i) what has been realized from a business – ca. 1628. (ii) The evidence that something is coming from a particular place and obtained from somewhere– ca. 1785 (iii) The written document showing the ownership of a work of art or an antique, when that could be used as a pointer to authenticity or quality; a documented record – ca.1867. For the study of African art objects, all these meanings should be considered together starting from the rear in that order because they have relevance to the provenance study of African art objects.

Firstly, the ownership and history of ownership of African art objects is necessary: the historical,

social, and economic context in which the works of art or objects were created and collected is considered. How has each of the objects reached their current location? Through which paths do they take? What hands have exchanged them? Were they acquired legally; donated, purchased, or confiscated? The National Gallery Canada (NGCPRP n.d.) contributes that, the history of ownership can be also be sources of new academic disciplines like history of collecting, patronage, studies of change in taste overtime – now of African art objects. Secondly, meaning begs the question where does such African art object(s) come from? And thirdly, who are the people that have benefitted from such African art business? What are the likely assets attained through the proceeds? Are there any records of sales, and so on?

To answer the question why is art provenance necessary for art African historical studies? And how should provenance of African art objects done? Smith (2013) and Reynolds (2008) alerts that provenance research is time consuming and labor intensive; sometimes the result of the research is very rewarding with the effort. Therefore, Smith (2013) observes that provenance is of increasing importance in the art community because museums, galleries, and collectors wish to avoid looted works of art and therefore wish to confirm that such is genuine. In addition, Reynolds (2008) affirms that research has shown that there are possibilities for a work of art being misidentified, misattributed and having no proper record elsewhere; challengingly, in some cases where there are records, some works of art look alike, when that happens, all evidence needs to be closely through laboratory means.

National Gallery of Canada (NGCPRP n.d) Provenance Research Project and the Metropolitan Museum of Art Provenance Research Project (MMAPRP n.d.) observes several reasons why provenance is very important as long as we need the understanding of the historical, social and economic situations under which work of arts were collected and created. Documents from archives such as dealer records, sales catalogues and information from previous owners must be examined to be able to trace and record an object's history; documentations does not always survive, works are collected and sold anonymously because name of collectors are believed to be confidential, some art dealers and their records are no longer available when such dealers are out of business – witting for African art objects.

## 7. Functions of Art Provenance

**Confirmation:** One of the functions of art provenance is to confirm the originality of what a work of art claims to be i.e. to ascertain that the actual work of art was created by a particular artist (creator) and not another person. At this stage, the evidence of forgery and restoration is sought after; the history or small literature about the work, the artist and the possible ownership history (tracing backwards the genesis of the work) and individuals that might have had contact with the work. The date of creation, artist, subject, and so on are confirmed.

**Cultural and Historical Information:** Provenance brings to the fore the associated cultural and historical information attached to the work of art or object; this will form a basis for understanding the context and content under which the work of art or object has been created. Such history could reveal the socio-cultural mobility of the artist as well as the owner(s) i.e. why, when and where and who were interested in the work of art or object.

**Legality:** Provenance establishes legality and value of works of art. Legal and authentic works of art attracts audience, buyers and facilitate increase in market value; illegally excavated, reproduced, transferred, acquired, or disputed attracts less value and penalty which eventually deters collectors. Provenance determination must seek thorough documentation and the legality or otherwise of works of art.

**Acceptance:** After a completed provenance exercise, certificate of authentication must be issued due to the work of art or object; this makes the work to be more genuine and easily acceptable for sale, auction, transferred, and so on, without any fear or bias about the value of such work of art or object.

**Certification:** The work of an art historian is to certify provenance queries and answers -reason the art historians need to be armed with technical tools of provenance determination. This is the last stage of provenance determination. To date, there are evidences of fake antiquities and numerous forged works of art. Many works of art are on sale with falsified provenance; therefore, a certificate of authenticity (COA) which attests to the authorship and every claim about the work of art must be issued. This is very useful in art litigation (jurisprudence) because it will present the bedrock of the bundle of material evidence needed in court of law. One should not be surprised that all the aforementioned attributes are commonalities shared by art history and archaeological disciplines.

## 8. The Meeting, Divergence of Art History, Archaeology, Provenance Studies, and Art Authentication

Art history and archaeology seeks to clarify and verify information about material things believed to have been manufactured and used within a society which is enshrined in a particular cosmological system. According to Prudencio (2008), Archaeology believed pottery for instance, is a source of insights into people and cultures being the first synthetic materials humans created beginning with the recognition of clay as a principal raw material.

Reynolds (2008) observes that, of great importance to both Art History and Archeology is the visual inspection of the material dealing with morphological and stylistic attributes. And as a supplement, archaeology seeks for the physical, mineralogical and chemical characteristic of the material. In recent times, Art historical studies have embraced the detailed physical and chemical examination of all materials in question. Archeologists have used material compositional profiles obtained from ceramics shards and other materials in the direction of tracing artifacts from their discovery to their actual source or origin. Such information obtained is used to unravel many questions bothering around production techniques, routes of trade and exchange of raw materials. Archaeology however shared borderlines with art history in the areas of style, typology, shape, size, and so on with the principal motive of classification.

Art historical studies seek much information after the content and contextual backgrounds under which work of art or objects are produced in addition to other morphological studies. The issues of cultural and trade exchange embraced by archaeology also fall in line with interaction between people, exchange studies that are based on compositional information. This resultantly provides insights into the cultural processes of enculturation and ethno-genesis which provide insight into the culture of people. Material compositional analysis provides insight into movement of materials, and the nature of materials especially for metallic and ceramic objects. Art History and Archaeology embraces compositional data which have implication for understanding various manufacturing techniques, movement of raw materials and products. The two areas of study therefore need art provenance and authentication determination. Archaeology has borrowed much in terms of methodology and techniques from art history, while art history is in a marriage of expediency and necessity with archaeology.

Peacock (1970) and Bishop *et al.* (1982) in their observation have identified that mineral assemblages is a scientific as well as an artistic endeavor; and that socio-economic processes of craft production allows the identification of some form of social interaction that take place during procurement of raw materials and the making of products. In consonance with the foregoing, Righter (1997), Roe (1989), and Keegan (2000) focused on examining the stylistic motifs as well as morphological attributes of the pottery in the Caribbean ceramic studies.

## 9. Challenges in the Study of Cultural Heritage and Materials

As observed by Lo Dennis (2004) that, for decades, the history and development of the arts and crafts, art connoisseurship were determined using the sensory organs of sight and touch alone, Taylor (2000) also posits that, the advent of modern technology has advanced the course of evidence

gatherings, measurements, and the endorsement of written historical records. Man-made artifacts have been dated using Carbon - 14 dating. Computer method of analysis have also been found to be more accurate than highly trained connoisseurs, art historians and artists, though not replacing art historical methods of connoisseurship but enhance and extend them. In recent times, there are websites addressing analysis of art through computer image. The ever increasing sophistication in knowledge has contributed the number of ways how things can be managed or utilized skillfully. According to Mazurkewich (2000), to be sure of the exact nature of things had become a serious concern in the art industry today. There are reports of fakes and modern copies of expensive Chinese ceramics of Yuang or Ming dynasties: these were noted to have been exposed to X-rays to simulate Thermoluminescence results by fraudsters.

Martinez *et al.* (2002); Barni *et al.* (2005); Berezhnoy *et al.* (2005, 2007, 2008); and Maitre *et al.* (2001) mention that after the discovery of X-rays in the 19<sup>th</sup> century, it has been possible to reveal under drawings of paintings; infra-red photography and reflectography are also in use in art analysis. Multispectral, fluorescence and ultra-violet imaging came in use to reveal compositional analysis of works of art. Stork and Johnson (2006); Stork, Coddington and Bentkowska-Kafel *eds.* (2010) have also observed that in recent years computer algorithms were developed from computer vision for image interpretation. Stork *et al.* (2009) also point out that one of the most explored areas of computer analysis of art is the analysis of marks of drawing tools most especially the use of statistical pattern recognition of visual properties of brushstrokes corresponding to a particular painter or marking tool. Other analysis carried out in art historical studies include optical analysis of paintings as reported by Hockney and Falco (2000); Hockney (2001); Steadman (2002); Abas (2004); and Bucklow (1998).

Lo, Denis (2004) discover that, Organic composition of painting pigments had also been carried out using Raman Spectroscopy (RS) and has yielded many undetectable parameters by the human sensory organs. Inductively Coupled Plasma- Mass Spectrometer (ICP-MS) has also been used for artifacts authentication. Aitken (2004) confirms XRF (X-Ray Fluorescence), PIXE and Thermoluminescence are non-destructive means of carrying out compositional analysis which have found their ways into dating and authentication of works of art.

Lyu *et al.* (2004) establish that paintings and drawings have been authenticated today using a multi-scale, multi-orientation decomposition analysis called Wavelets. Computerised analysis of artists' brush strokes have also been carried out for use by art historian for authentication process. Johnson (2007) and Johnson *et al.* (2007) carried out computerised analysis of Vincent Van Gogh's painting brushstrokes and generated a set of one hundred and one (101) databases for authenticating Van Gogh's brushworks. Hendricks & Guldof (2005), Hendricks & L. Van Tulborgh (2006) have also analysed Van Gogh's paintings. Pelagotti *et al.* (2008) also submit that sophisticated imaging techniques have also been in use in the past, and in recent decades for digital imaging authentication in the study of art. Rice (1987) state that, chemical and mineralogical analyses of artifacts (and other found objects) have provided evidences for the understanding of human past to solve the notoriously difficult task of relating individual object to its specific origin: modern investigators are today forced to draw conclusion from field and laboratory analyses. For example, Geological tools are becoming increasingly important in the interpretation of data retrieved from archaeological sites in studying ancient relics

## 10. The Applications of Energy Dispersive X-Ray Fluorescence (EDXRF) Systems in Heritage Study and Management

With the birth of a digital world and the revolution in technology today, the production and use of portable handheld analytical instruments have facilitated the analysis of many things. Different types of analytical instruments have been manufactured and supplied commercially by several companies based on either the x-ray or  $\gamma$ -ray excitation sources for analysis of works of art. PEDXRF (portable energy dispersive x- ray fluorescence) have been identified as an invaluable tool in the identification

of organic and inorganic pigments used in painting; such pigments can be characterized by the identification of the presence of elements in pigments can be recognised. Experience has shown that old painting have been restored before sales; spots and restored areas are detectable using PEDXRF equipments. In addition to fake works of art, layers and underpaintings as well as pollution effects on objects and painting are detectable using the PEDXRF equipment on painting surfaces.

In art related applications, the use of portable handheld energy dispersive x-ray fluorescence equipment is fully explained by Casareo *et al.* (2008). The portability advantage of PHEDXRF equipment in the analysis of objects that cannot be transported to the laboratory especially for works of art like painting, frescoes, monuments, statues, and so on is emphasised. Some examination requires 'insitu' analysis, museums and excavation sites gives more relevant examples. Marabelli *et al.* (2005) and loele *et al.* (2007) report the use of portable EDXRF equipment in the analysis of pigments in paintings; Marabelli *et al.* (2005); Cesareo *et al.* (2003) report the examination of gold objects; Cesareo *et al.* (2006,2007,2008) report investigation of bronzes with such equipment. Other attributes derived from that equipment in painting application includes the identification of the particular pigments used by the artist which is of paramount importance in the history of such works of art.

## 11. Summary, Conclusion and Recommendations

Art historical studies seek the verification of information about material things believed to have been created and used within a society's cosmological system. The visual inspection of such materials should not rest with morphological and stylistic attributes alone. As a supplement to formal attributes, mineralogical and chemical characteristic of the material with detailed physical and chemical examination must be carried out. Art historical studies seeks much after the content and contextual backgrounds under which objects are produced, in addition to its morphological studies; the issue of Compositional analysis would provide insight into the nature of materials.

Compositional data of works of art from Africa have implication for understanding various manufacturing techniques, movement of raw materials and products. It is now a recognised fact for art history that mineral content information is as well a scientific as an artistic endeavor in the processes of art and craft production. Technology has advanced the course of evidence gathering, measurements, and the validation of art historical records. The physical measurement and data analysis of artifacts are likened to cataloguing of human dimensions for the purpose of identification e.g. DNA, height, weight, foot, molecular studies, finger prints, and so on.

The chemical and mineralogical analyses of artifacts and other found objects will further provide evidences for the understanding of human past. The task of studying ancient African relics is the notoriously difficult in relating individual object to its specific origin. Modern investigators draw conclusion from field and laboratory analyses. Today, with the advent of the digital world and revolution in technology, different types of analytical instruments have been manufactured and supplied commercially for the identification of organic and inorganic materials even in the analysis of objects that cannot be transported to the laboratory. African governments, research institutes, art historical community, academia, art historians must not distant themselves from technology enhanced art provenance investigation for methodological and technical reasons.

## References

- AAMGPR (2005). American Association of Museums' Guide to Provenance Research American Association of Museums. Vitalizing Memory. Washington D.C.: American Association of Museums.
- Abas, F.S. (2004). Analysis of craquelure patterns for content-based retrieval. Ph.D. thesis, Southampton: University of Southampton, UK, 2004.
- Activation Analysis – A Technical Report Submitted to the Ministry of Culture and Fine Arts, Kingdom of Cambodia July 2010, University of Hawai'i at Mānoa Royal University of Fine Arts Lower Mekong Archaeological Project, p.1.

- Aitken, M.J. (2004). Thermoluminescence Dating (Academic Press)
- Ardika, I.W. & Bellwood, P. (1991). Sembilan: the beginnings of Indian contact with Bali. *Antiquity* 65 (247), pp. 221–232.
- Arnold, D.E., Neff, H., Bishop, R.L., (1991). Compositional analysis and “sources” of pottery: an ethno-archaeological approach. *American Anthropologist* 93, 70–90.
- Arnold, D.E., Neff, H.A., Bishop, R.L., Glascock, M.D., (1999). Testing interpretive assumptions of neutron activation analysis Contemporary pottery in Yucatán, 1964 – 1994. In: Chilton, E.S. (Ed.), *Material Meanings, Critical Approaches to the Interpretation of Material Culture*. University of Utah Press, Salt Lake City, 61–84.
- Bagley, R. W. (1987). *Shang Ritual Bronzes in the Arthur M. Sackler Collections*. Cambridge: Harvard University Press.
- Barker, H. (1965). Examination of the Ife Bronze Heads. *Man*, 65, pp. 23–4.
- Barni, M., Pelagotti, A., & Piva, A. (2005). "Image processing for the analysis and conservation of paintings: Opportunities and challenges," *IEEE Signal Processing Magazine* 22(5), pp.141–144.
- Bellina, B. (2003). Beads, social change and interaction between India and South-east Asia. *Antiquity* 77, pp. 285–297.
- Berezhnoy, I. E., Postma, E. O., & van den Herik, H. J. (2005). Computerized visual analysis of paintings, In *Proc. Int. Conf. Assoc. for History and Computing*, pp. 28–32.
- Berezhnoy, I. E., Postma, E. O., & van den Herik, H. J. (2007). Computer analysis of van Gogh's complementary colours, *Pattern Recognition Letters*, vol. 28, no. 6, pp. 703–709.
- Berezhnoy, I. E., Postma, E. O., & van den Herik, H. J. (2008). Automatic extraction of brushstroke orientation from paintings. *Machine Vision and Recognitions Journal*, 2008.
- Bishop, R. L., Rands R. & Holley, G.R. (1982). Ceramic compositional analysis in archaeological perspective In M.B. Schiffer (ed.), *Advances in Archaeological Method and Theory*, 5, New York, pp.275–330.
- Bucklow, S. (1998). "A stylometric analysis of craquelure," *Computers and Humanities* 31(6), pp.503–521.
- Cesareo, R. (2003). 'Non-destructive EDXRF-analysis of the Golden Haloes of Giotto's Frescos in the Chapel of the Scrovegni in Padua', *Nucl. Instrum. Methods Phys. Res.*, B211, 133–137.
- Cesareo, R., Gigante, G.E., Ridolfi, S. (2007). 'Analysis of Paintings and Alloys with Portable EDXRF-Equipments', *XRF Newslett.*, August, 10–11 (2007).
- Cesareo, R., Ridolfi, S., Castellano, A., Marabelli, M., Buccolieri, G., Quarta, S., Gigante, G.E. (2006). 'From Giotto to De Chirico to Verrocchio: Analyses of Paintings and Historical Bronze Alloys Availing of Portable EDXRF Equipment', *J. Neutron Res.*, 14, 17–27.
- Cesareo, R., Ridolfi, S., Marabelli, M., Castellano, A., Buccolieri, G., Donativi, M., Gigante, G.E., Brunetti, A., & Medina, M.A.R., (2008), Portable systems for energy-dispersive X-ray fluorescence analysis of works of art. In Potts, P.J., and West, M. (Eds.), *Portable X-ray fluorescence spectrometry: capabilities for in situ analysis*. Cambridge: The Royal Society of Chemistry, 208–246.
- Choeung Ek, & Village 10.8, Kingdom of Cambodia, using Instrumental Neutron
- Craddock, P. T. & Picton, J. (1986) Medieval copper alloy production and West African bronze analyses - part II. *Archaeometry*, 28, 1, pp. 3–32.
- Craddock, P.T., Ambers J., Hook, D.R., Farquhar, R.M., Chikwendu, V. E., Umeji, A.C. & Shaw, T. (1997). Metal Sources and the bronzes from Igbo-Ukwu, Nigeria. *Journal of Field Archaeology*, 24, pp. 405–29.
- Drewal, H. J. & Scildkrou, E. (2010). *Kingdom of Ife*. British Museum Press, London.
- Fagg, W. B. & Underwood, L. (1949). An examination of the so-called Olokun head from Ife, Nigeria. *Man*, 49, pp. 1–9.
- Fehrenbach, S. (2010) Compositional Analysis of 35 Ceramic Sherds from Phum Snay, Prohear, *Field Archaeology*, 24, 405–429.
- Goucher, C. L, Teilhet, J. H., Wilson, K. R. & Chow, T J. (1978). Lead Isotope Analyses and Possible Metal Sources for Nigerian “Bronzes”. *American Chemical Society*, Westerville, Ohio, pp. 278–92.
- Harper, P. & Meyers, P. (1981). *Silver Vessels of the Sasanian Period*. Royal Imagery, Vol I, New York: metropolitan Museum of Art.
- Hendriks, E. & L. van Tilborgh (2006). New Views on Van Gogh's Development in Antwerp and Paris: an Integrated Art Historical and Technical study of His Paintings in the Van Gogh Museum, Ph.D. thesis, Faculty of Humanities, University of Amsterdam, vol.1, Nov. 2006.
- Hendriks, E. & M. Geldof (2005). Van Gogh's Antwerp and Paris picture support (1885–1888):
- Hockney, D. (2001) *Secret knowledge: Rediscovering the lost techniques of the old masters*, Viking Studio, New York, NY.
- Hockney, D. & Falco, C.M. (2000). Optical insights into Renaissance art, *Optics and Photonics News* 11(7), pp. 52–59.

- Ige, O. A., Ogunfolakan, B. A., Ajayi E.O.B. (2009). Chemical Characterization of some potsherd pavements from parts of Yorubaland in Southwestern Nigeria. *Journal of Archaeological Science* 36 (2009) 90 – 99.
- Ige, O.A., Okrusch, M., Schuller, U., Smadricke, E., & Cook, N. (1998). The metamorphic mafic-ultramafic rocks of Ife-Ilesa Schist Belt, SW. Nigeria. *African Journal of Geo.*, Paris vol.26: pp 593 – 618.
- Ige, O.A., Swanson, S. E. (2008). Provenance studies of Esie sculptural soapstone from southwestern Nigeria. *Journal of Archaeological Science*, 35 [2008]. 1553-1565. Elsevier Ltd.
- Ioele, M., Marabelli, M., Ridolfi, S., Cesareo, R., (2007). Indagini non distruttive per lo studio delle tecniche pittoriche e per il restauro in *La Sacra Conversazione di Palma il Vecchio*, Ministero degli Affari Esteri e dei Beni Culturali, ARTEMIDE.
- Joel, E.C., Sayre, E.V., Vocke, R.D. & Willett, F. (1995). Stable lead isotope characterisation of various copper alloys used in West Africa: an interim report. *Journal of the Historical Metallurgy Society*, 29 (1), pp. 25-33.
- Johnson, C. R. Jr., ed., (2007). Workshop on Image Processing for Artist Identification, *Proc. 1<sup>st</sup> Int. Amsterdam, the Netherlands*. <http://digitalpaintinganalysis.org/workshop/proceedingsIP4AI-1.pdf>
- Johnson, C.R, Jr.; E. Hendriks; I.J. Bereznoi; E. Brevedo; S.M. Hughes; I. Daubechies; J.Li; E. Postma; & J.Z. Wang. (2007). Image Processing for Artist Identification: Computerized Analysis of Vincent van Gogh's Painting Brushstrokes, pp.1-15
- Jones, M., Craddock, P. & Barker, N. (eds.) (1990). *Fake? The Art of Deception*. Los Angeles: University of California Press.
- Keegan, W.F. (2000). West Indian archaeology. 3. ceramic age. *Journal of Archaeological Research* 8(2):135-167.
- Lewis, P.H. (1990). A Definition of Primitive Art 1, *Fieldiana Anthropology*, Vol.36, No.10, Chicago Natural History Museum, pp.231-232.
- Lo, Dennis (2004). The Role of Physical Science in the Study of Cultural Heritage, *AAPPS Bulletin* June 2004, pp. 21-25.
- Lyu, S., Rockmore, D. & Farid, H. (2004). A digital technique for art authentication, *Proc National Academy of Sciences*, vol. 101, no. 49, pp. 17006-17010. December 7, 2004.
- Maitre, H., Schmitt, F. & Lahanier, C. (2001). 15 years of image processing and the fine arts, *Proceedings International Conference on Image Processing (ICIP)* 1, pp. 557– 561.
- Marabelli, M., Santopadre, P., Ioele, M., Cesareo, R., Castellano, A., Verit, M. (2005) 'a', 'Metal leaves utilized for decoration of Giotto's mural paintings', in *Bollettino d'arte, volume speciale: Giotto in the Scrovegni Chapel*, Istitupoligrafico dello Stato, 121-145.
- Martinez, K., J. Cupitt, J., Saunders, D. & Pillay, R. (2002) "Ten years of art imaging research," *Proceedings of the IEEE* 90(1), pp. 28-41.
- Mazurkewich, K. (2000) Art & Money Section, *Wall Street Journal*, September 1 (2000).
- Miksic, J. & Yap, C. T. (1990). Fine-Bodied White Earthenwares of Southeast Asia: Some X-Ray Fluorescence Tests. *Asian Perspectives* 28(1):45-60.
- Miksic, J. & Yap C.T. (1992) Compositional Analysis of Pottery from Kota Cina, North Sumatra: Implications for Regional Trade during the Twelfth to Fourteenth Centuries A.D. *Asian Perspectives*, Vol. 31. no. 1 *Asian Perspectives* 31(1)
- MMAPRP (n.d.). The Metropolitan Museum of Art Provenance Research Project [http://www.metmuseum.org/Works\\_of\\_Art/provenance/index.asp](http://www.metmuseum.org/Works_of_Art/provenance/index.asp)
- Moss, A. A. (1949). Further light on the 'Olokun' head of Ife. *Man*, 49, p. 120.
- NGCPRP (n.d.). The National Gallery of Canada's Provenance Research Project.
- Olabanji, S.O., Olanrewaju, V.O., Onabajo, O.O. (1990). PIXE analysis of museum soapstone sculptures from Esie, Southwestern Nigeria. *Nuclear instruments and methods in Physics Research* B47, pp. 415-420.
- Olaleye-Otunla, O. J. (2020a). *Inventorying Ita Yemoo Museum, Ile-Ife: Yoruba Pottery Collection*. Mauritius: Scholars' Press, 277pp. ISBN: 978-613-8-94287-6.
- Olaleye-Otunla, O. J. (2020b). *Yoruba Pottery Objects: Material Compositional Studies of Yoruba Pottery Objects*. Mauritius: Scholars' Press, 117pp. ISBN: 978-613-8-94287-0.
- Peacock, P. D. S., (1970). Scientific analysis of ancient ceramics: a review, *World Archaeology*, 1, 379-89.
- Pelagotti, A., Mastio, A. D., Rosa, A.D., & Piva, A. (2008) "Multispectral imaging of paintings," *IEEE Signal Processing Magazine* 25(4), pp. 27-36.
- Platte, E. (2010). *Bronze Head from Ife*. British Museum Press, London.
- Prudêncio, M. I. (2008). Ceramic In Ancient Societies: A Role For Nuclear Methods Of Analysis Instituto Tecnológico e Nuclear, EN 10, 2686-953 Sacavém, *Portugal Journal of Caribbean Archaeology Special Publication #2*, 2008 45, ISSN 1524-4776.

- Pryce, T. O. (2008). Chs. 3, 8, and 9 of Prehistoric Copper Production and Technological Reproduction in the Khao Wong Prachan Valley of Central Thailand. Ph.D. Dissertation, UCL Institute of Archaeology, University College London.
- Reconstructing choices, *Art Matters: Netherlands Technical Studies in Art History*, vol.2, pp.39-75.
- Reedy, C.L. & P. Meyers (1987). An interdisciplinary method for employing technical data to determine regional provenance of copper alloy statues. In *Recent Advances in the Conservation and Analysis of Artifacts*, compiled by J.Black: 173-178.London: Summer School Press.
- Reynolds, L. (2008). An Art Provenance Research Guide for the Researcher and Librarian: A List of Resources. A Master's paper submitted to the faculty of the School of Information and Library Science of the University of North Carolina at Chapel Hill in partial fulfillment of the requirements for the degree of Master of Science in Library Science Chapel Hill, North Carolina April 2008, 45pp.
- Rice, P. M., (1987). *Pottery analysis: a Source Book*, The University of Chicago Press, Chicago.
- Righter, E. (1997). The ceramics, art, and material culture of the early ceramic period in the Caribbean Islands. In *The Indigenous People of the Caribbean*, edited by S. M. Wilson, University Press of Florida, Gainesville, pp. 70-79.
- Roe, P.G. (1989), A grammatical analysis of Cedrosan Saladoid vessel form categories and surface decoration: Aesthetic and technical styles in early Antillean ceramics. In *Early Ceramic Population Lifeways and Adaptive Strategies in the Caribbean*, edited by P. E.Siegel, pp. 267-382. BAR International Series 506, Oxford.
- Rubinstein, R. (1986). Michelangelo's Lost Sleeping Cupid and Fetti's Vertumnus and Pomona. *Journal of the Warburg and Courtauld Institutes*. 49: 257-259.
- Shaw, T. (1970). *Igbo Ukwu*. Faber & Faber, London.
- Smith S.E. (2013). What is the Provenance of a Painting? Follow @ wiseGEEK 2003-2013 Conjecture Corporation.
- Soanes, C., (2004.) *The Concise Oxford English Dictionary*. New ed. Oxford: Oxford University Press. Spring 1992.
- Steadman, P. (2002). *Vermeer's Camera: Uncovering the truth behind the masterpieces*, Oxford, UK: Oxford University Press.
- Stone, R.S. (1982). Antico and the development of bronze casting in Italy at the end of the Quattrocento. *Metropolitan Museum Journal* 16:87-116. In: *Nuclear Chemistry: New Research* ISBN: 978-1-60456-957-5 Editor: Axel N. Koskinen, pp. 51-81 © 2008 Nova Science Publishers, Inc.
- Stork, D. G., Coddington, J. & Bentkowska-Kafel, A. eds., (2010) *Computer vision and image analysis of art, SPIE/IS&T*, Bellingham, WA.
- Stork, D.G. & Johnson, M.K. (2006). Computer vision, image analysis, and master art, part ii, *iee multimedia*, 14(3), pp. 12-17.
- Stork, D.G., Meador, S. & Noble, P. (2009). Painted or printed? Correlation analysis of the brickwork in Jan van den Heyden's View of Oudezijds V oorburgwal and the Oude Kerk In Amsterdam," in *Electronic Imaging: Human vision and electronic imaging XIV*, B. E. Rogowitz and T. N. Pappas, eds., 7240, pp. 72401O1-10. SPIE/IS&T, Bellingham, WA.
- Taylor, R.E. (2000). Fifty Years of Radiocarbon dating, *American Scientist* 88, 60 (2000).
- The Oxford English Dictionary* (2nd ED.) O.U. P., pp. 795-796, 1989.
- The Webster's New 20th Century Dictionary*.
- Underwood, L. (1949). *Bronzes of West Africa*. Alec Tiranti, London.
- Vansina, J. (1984). *Art History in Africa*, London, and New York: Longman, pp. viii,3,19,24.
- Vincent, B. (2000). Pottery Technology Studies in Southeast Asia: A Review. In *Southeast Asian Archaeology 1998*. Proceedings of the 7th International Conference of the European Association of Southeast Asian Archaeologists, Berlin, 31 August – Hull, Center for Southeast Asian Studies, University of Hull. 4 September 1998, pp. 265-280.
- Vuong Q-H, Ho M-T, Nguyen H-KT, Vuong T-T, Tran K, Ho MT. (2018). "Paintings Can Be Forged, But Not Feeling": Vietnamese Art—Market, Fraud, and Value. *Arts*. 7(4):62. <https://doi.org/10.3390/arts7040062>
- Werner, O. (1970). Metallurgische Untersuchungen der Benin-Bronzen des Museums für Volkunde Berlin. *Baessler Archiv.*, N.F., 18, pp. 71-153.
- Werner, O. and Willett, F. (1975). The composition of brasses from Ife and Benin. *Archaeometry*, 17 (2), pp. 141-56.
- White, J. C. & Hamilton, E.G. (2009). The Transmission of Early Bronze Technology to Thailand: New Perspectives. *Journal of World Prehistory* 22:357-397.
- White, J. C. & Pigott, V. (1996). From Community Craft to Regional Specialization: Intensification of Copper Production in Pre-state Thailand. In *Craft Specialization and Social Evolution: In Memory of V. Gordon Childe*, edited by B. Wailes, University Museum Symposium Series, Volume VI, Philadelphia, pp. 151-175.

- Willett, F. (1959). Bronze figures from Ita Yemoo, Ife, Nigeria. *Man*, 59, pp. 308-11.
- Willett, F. (1964). Spectrographic analysis of Nigerian bronzes. *Archaeometry*, 7, pp. 81-3.
- Willett, F. (1967). *Ife in the History of West African Sculpture*. Thames and Hudson, London.
- Willett, F. (1976). True or False? The false dichotomy. *African Arts*, 9 (3), pp. 8-14.
- Willett, F. (2004). *The Art of Ife: A Descriptive Catalogue and Database* (CD-ROM). Hunterian Museum and Art Gallery, University of Glasgow, Glasgow.
- Willett, F. & Fleming, S.F. (1976). A catalogue of important Nigerian copper-alloy castings dated by thermoluminescence. *Archaeometry*, 18 (2), pp. 135-46.
- Willett, F. & Sayre, E.Y. (2006). Lead isotopes in West African copper alloys. *Journal of African Archaeology*, 4 (1), pp. 55-90.
- Williams, D. (1974). *Icon and Image*. Allen Lane, London.
- Yeide, N. H., (2001). The AAM Guide to Provenance Research. Washington, DC: American Association of Museums, 2001, pp. 21-34.