IDENTIFYING THE REAL THING

(Prepared by D. van der Reyden of SCMRE, for School for Scanning, Sponsored by the National Park Service and Managed by the Northeast Document Conservation Center, September 11-13, 1996, New York City)

INTRODUCTION

People often go to museums, libraries and archives to see "the real thing." But "the real thing" can be "seen" in many ways. Appearance can be observed on exhibit or on-line, or measured in a laboratory. However, materials and technology can be revealed only by stylistic, historical and scientific analysis of "the real thing." The findings of these various types of analysis by museum specialists (such as curators, historians, scientists, archivists, conservators and other experts) can then be communicated to or "seen" by various audiences, ranging from the general public to scholars, visiting on site or working on-line. The media through which findings are "seen" can include exhibits, publications, computer programs, lectures and videos, produced with the aid of other museum professionals (specializing in exhibition, registration, publication, public relations, education, research, collections management and computer science). But, consider this: when you look at an image on exhibition or on-line, do you know if that object is "real"? How can you tell? Why does it matter?

THE POWER OF "THE REAL THING"

Why is "the real thing" so important to people? Objects are valued not only for their appearance, but also for their tremendous symbolic power. Any object can have symbolic and visual power. However, only "the real thing" contains the evidence to support its symbolic and visual importance. Evidential, artifactual, value is dependent on the material composition of the object. Reconciling the symbolic, visual, artifactual and evidential value of "the real thing" requires the convergence of stylistic, historical and scientific analysis. Such expertise is often provided by the collaboration of many experts found in museums like the Smithsonian.

What do people really see when they look at an object on exhibit, in a book or on-line? What they actually see is a virtual reality, based on the appearance of the real thing. The appearances of objects have tremendous power to alter the course of history and human lives. But mere superficial appearances can be misleading.

Consider, for instance, something as simple as a manuscript. In fact, consider three famous manuscripts: "Howard Hughes' Autobiography," "Hitler's Diary," and the Mormon Church's "Salamander Letter." What do these documents have in common? Each had the power to greatly influence issues of legal, historical or religious significance. Each had this power, if, that is, they were "the real thing". But as it turned out, each was actually proven to be fake. The truth however exacted a costly toll, including the loss of human lives.(1)

Take, for instance, the case of the "autobiography" of Howard Hughes. The reclusive millionaire Hughes supposedly broke his seclusion to dictate an autobiography to author Clifford Irving. Hughes later protested that he had not communicated with Irving, and lengthy litigation began. No less than three handwriting experts authenticated letters that Irving claimed were from Hughes. These experts attributed the letters to Hughes based on the "fact" that the size and the spacing of the words written in the letters were characteristic of the style of Hughes' own writing. The resulting long and expensive legal dispute might never have been settled, had not Irving finally confessed to forging the letters.

The case of the "autobiography" illustrates the legal importance of verifying "the real thing." The case of the "Hitler diaries" illustrates the potential power of objects to revise political and social history. In the early 1980's Newsweek magazine published a special report on "Hitler's 'Secret' Diaries: How they could rewrite history." The diaries were finally exposed as fakes; in part because some of the materials used to make them were not invented until after Hitler's death. Modern optical brighteners were detected in the paper when the pages were examined under special illumination (such as ultraviolet light). The binding of the diaries contained modern synthetic materials, identified when samples were examined under high powered magnification (such as a stereo or polarized light microscope).

One of history's most extreme cases of forged documents threatened to undermine one of the world's most powerful religions. The case of the "Freeman's Oath" and the "Salamander letter", resulted in the actual loss of life. In the mid-80's, a Utah dealer, Mark Hofmann, presented the Mormon Church with a series of documents, which if real would have greatly embarrassed the Church. As suspicion grew about the authenticity of the documents offered by Hofmann, he began to feel cornered. To protect himself, and provide a diversion, he resorted to murder, engineering the death of three people by blowing them up with home-made bombs. He eventually injured himself while transporting new bombs. When arrested, he ultimately confessed that he faked the documents; to make them appear authentic, he used historic paper and ink recipes. He claimed that he even artificially aged the documents by oxidizing them with hydrogen peroxide. This is what lead to his downfall and arrest in the first place. His creations had become suspect when examination, under high powered magnification (such as a stereomicroscope), revealed that the ink's medium of gum arabic was cracking in a strange manner, totally inconsistent with what would happen during "natural" aging.

HOW TO IDENTIFY "THE REAL THING"

How can you tell that an object is "the real thing"? Identifying "the real thing" requires looking beyond the mere superficial surface appearance of objects. Taking objects at "face value" can lead people to misunderstand or misrepresent the true value of objects. The legal, historic, social or scientific significance of objects depends on that object's being "the real thing". Although any object can have "symbolic value," only "the real thing" is worthy of its "symbolic value" by virtue of its evidential value. Evidential value can only be supported by full and accurate characterization of "the real thing." Characterizing objects such as a print or manuscripts can require the combined expertise of curators, historians, connoisseurs, archivists, conservators, and scientists. To determine whether an object is "the real thing," that object must be analyzed in many ways.(2) Three important ways to examine objects for authenticity, illustrated in Table 1, include:

- Stylistic Analysis
- Historical Analysis
- Scientific Analysis

Stylistic Analysis
Stylistic analysis, based on a comparison of the style of an unidentified object to a known body of work, can provide clues about three important aspects of the origin of "the real thing"(3)

- Place of Origin
- Period of Origin
- Purpose of Origin

Place of Origin: Style may vary depending on where an object originated. For instance, consider objects from China or Europe (Ill. 1 and 2). Each of these geographic locations, or countries, has distinctly different traditional designs and materials that characterize objects from those countries. For example, a print with Chinese characters might be expected to be from China (Ill. 1). An image showing the influence of Western Civilization might have European origins (Ill. 2)

Period of Origin: Stylistic analysis can also provide clues as to when an object was made, such as during the Victorian or Modern period (Ill. 2 and 3). A mix of classical motifs from around the world (Ill. 2) might characterize the time of the Victorian Empire (Ill. 2). On the other hand, total abstraction is generally considered a modern phenomenon (Ill. 3).

Purpose of Origin: Stylistic analysis should include an understanding of the purpose of an object. For instance, the style of a drawing may vary depending on whether it was proposed be a quick sketch, a working sketch, a preparatory drawing, a detail study, or a finished presentation piece (Ill. 2). Clues to purpose can be found in the composition of the design, such as a few strokes for a quick sketch or modeled shading for a finished piece. Clues can also be found in the composition of materials and techniques, such as a drawing hand-sketched with chalk or a print hand-pulled from an etched and inked metal plate.

Stylistic analysis might lead to the identification of the general school or specific maker responsible for "the real thing", or to which the object might be attributed. But sometimes an object might appear to be one thing and actually be another (Ill. 4 and 5). There are many ways in which "the real thing" might be imitated. Some printing processes (such as soft-ground etching or lithography), can accurately copy the appearance of original drawings, watercolors, etc. Detecting these copies might require special illumination techniques (such as raking light across the surface of paper) or high magnification (achieved by a stereoscopic microscope). One modern day dilemma for manuscript collectors are autopens and signa signers that might have been authorized by the owner of the signature. In some cases, such signatures can be difficult to detect. Not all objects are copied with an intent to deceive. But if a forger uses traditional materials and techniques to imitate the style of the original, it can be especially difficult to detect whether an object is an original, a copy, or a fake.

Sometimes magnification alone is not enough to detect a clever fake. With an object that is consistent in style and composition of materials, but still suspect, one needs to think in terms of the maker's intent: how details of the design's composition (space, light, form, and lines) are define; how the qualities of line and color are expressed; and how well-executed and characteristic of the maker the piece is. Take, for example, an original manuscript (i.e. written by hand) as compared to a forgery, also hand-written. Forensic experts note that original manuscripts generally have writing that shows speed, consistency, uniform strength, pressure and carelessness. There should be backflow of ink only where the ink crosses over letters or where a refill of newer ink might backflow into the lines of the old ink. Fiber alignment on the paper surface can indicate the direction of a stroke to confirm whether it is correct. Words would rarely have breaks within them, and they would begin and end with flying strokes. A forged manuscript, however, might show a slow, hesitating hand with uneven pressure and both bold and weak strokes of ink intermingled. Letters might be reworked, or show a tremor not associated with age or ill health. Words might be stopped in the middle and then completed, with a puddle of ink backflow at the juncture. Or the ink might feather in creases, indicating that the paper was creased before the ink was applied.

Stylistic analysis can be confirmed or countered by historic and scientific analysis.

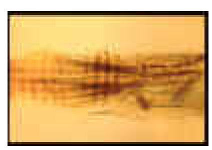
Historical Analysis

To be "the real thing", an object must be made with materials and techniques consistent with the style of the object and the history of materials and techniques associated with the time and place of origin of the object. To illustrate, consider the history of paper making and media technology, which is in itself full of mystery and intrigue. An historical analysis of objects on paper would need to include information on

- Materials and Techniques of Paper Making
- Materials and Techniques of Media

Materials and Techniques of Paper Making:






Although the origin of paper is disputed, early Chinese history records that in the second century AD, the scribe Ts'ai Lun presented the Emperor with his invention of papermaking. This invention, an obvious improvement over cumbersome predecessors like cave walls, clay tablets and parchment, revolutionized the art and science of writing in a way not rivaled again until the invention of the printing press and the PC (both of which are still dependent on that ancient support, paper!). The secret of papermaking was stolen in subsequent battles, and was adopted, adapted and spread throughout Asia and Europe over the next dozen centuries.(4) Depending on the location, paper would be made using fibers derived from various indigenous plants. The type of fibers used (mulberry, cotton, or banana...) are one clue to identifying a paper's origin or date (Ill. 1). In the West, paper was often made from fermented cotton and linen rags (hence the name "rag paper"). Other ingredients, added to change the chemical and physical properties of paper, may also provide clues as to origin and date of a sheet. For instance, to keep ink from spreading out on paper, ingredients like starches (rice, potato) or proteins (glue, gelatin) can be added to a pulp slurry or applied after a sheet is formed, to "size" paper. These sizing agents can also be used to identify origin and date, if they have not already degraded into oblivion with exposure to light, heat or moisture. The way the paper was made may also provide clues to dates. Paper making can be divided into two basic techniques:

- Hand-Made Paper
- Machine-Made Paper

Hand-Made Paper: Early paper was made by beaten plant fibers which were first dispersed in water. The fibers were then cast randomly upon a papermaking mold. Each mold consisted of a frame holding a porous screen. Mold types varied depending on their origin, but each imparted a characteristic impression on the sheet of paper. For instance, a paper made with a "laid and chain" mold (like fine "antique laid" writing paper) would have a pattern of a series of thin, parallel translucent lines (laid-lines) linked with occasional perpendicular lines marking the location of the "chain" stitches holding the screens' laid-lines in place. This configuration actually derives from early oriental mats (much like modern bamboo place mats). "Wove" paper has, instead of parallel lines, a weave impression imparted by fabric or wire mesh screens.

One common characteristic of true "hand-made" papers is a "deckled edge" where slippery paper fibers gather under the mold frame as water is dispelled. Another characteristic that can help determine the date and origin of papers is the "watermark," traditionally formed from a raised design on the mold, but which can be falsified by a "dandy roll" impression. Mold characteristics and finishing techniques can also affect surface texture. For instance, rough paper surface texture may be the result of the impression of the raised wires of the paper mold or the hairs of the felts used for couching. This gives paper its so called right side, (the felted side), and wrong side (the wire side which could cause skipping of the media). These don't have as much effect as the smooth surface induced by calendaring, which is caused by rolling over with a steel cylinder. This compressed effect can be distorted by the swelling of fibers following exposure to water. The paper might also be finished by a coating, which could be dissolved by water or solvents. Any coating can restrain a paper or be cracked by expansion and contraction of the paper fibers. Types of coatings would include the carbonate used for metalpoints, albumen coating on a photograph, or a gelatin glaze to increase the intensity of some colors, for instance in a Currier and Ives print, or a varnish on a paper map.

Machine-Made Paper: The industrial revolution of the early 19th century ushered in a revolution in papermaking, as demand and mechanization increased. "Machine-made" paper is cast upon moving belts, of sometimes enormous size, which can impart a distinct grain or machine direction as fibers aligned parallel to the direction the belt is moving. This in turn has a tremendous effect on the properties of strength and dimensional stability of paper, causing the paper to be easily torn or curled parallel to the grain. The strength of paper was further jeopardized in the 19th century by the use of highly acidic additives or ingredients, such as ground wood fibers (or mechanical pulp containing acidic lignin) and alum rosin size, both of which can cause paper to yellow and become brittle. Later, lignin in woodpulp could be dissolved out to make somewhat stronger chemical woodpulp. If sized with acid agents like alum rosin, as in notebook paper, such paper might yellow. But if sized with alkaline agents like calcium carbonate, like modern permanent-quality office paper, these high alpha cellulose papers are relatively stable.(5)

The history of paper continues to be replete with a seemingly infinite number of variables of furnish materials and formation techniques, from additives like bleaches to processes like fiber beating and supercalendering. And this is the information extractable from a single sheet of paper, by examining it in various lights, with different magnification, or by organic and inorganic analysis. For instance, watermarks on paper can be seen using raking or transmitted light. Modern additives, or specific types of stains, might fluoresce special colors under ultraviolet light (the same way a white shirt washed in a detergent with optical brighteners fluoresces in a disco blacklight!). Other additives can be identified with more complex instruments like X-ray Fluorescence or Dispersion (XRF or XRD), Fourier Transform Infrared Spectroscopy (FT-IR), or Scanning Electron Microscopic imaging (SEM) or Elemental Dispersive Spectroscopy (SEM-EDS). Fibers in a paper can be identified as stable cotton or acidic ground wood using simple analytical techniques on a polarized light stage microscope.

Materials and Techniques of Media:

Added to the wealth of information inherent in the base support of objects is the information inherent in the media found on objects. Media can be defined as the image or script found on paper or other objects. The history of media is as telling as that of paper.(6) For instance, before the advent of the pencil, artists and draftsmen making finely detailed drawings had to rely on a metal stylus dragged across a coated paper. Even the invention and fate of the seemingly ubiquitous graphite pencil was battered by history. The Napoleonic wars blocked the trade with England in graphite. This lead to adulteration of natural graphite with clay to create so-called artificial graphite in the late 18th century. It is easy to identify both these forms of graphite using SEM imaging. Pure graphite consists of platelets, while artificial graphite has platelets mixed with clay spheres. Consequently, a drawing with artificial graphite can not be dated earlier than the late 18th century regardless of whether its style is consistent with an earlier time or not. Many modern media are not what they claim to be, and this can make them difficult to identify. None-the-less, each type of media has characteristic application processes, compositions and aging properties. Media can be divided into several categories based, for instance, on whether it is applied by

- Drawing
- Painting
- Printing

Drawing Media: Early drawing media consisted of friable media like charcoal and chalk. Like media used later, such as graphite and pastel, these media have low amounts of binder ratios and so they don't adhere tightly to surfaces. Consequently, these media characteristically are friable and tend to smudge or smear with handling over time, unless housed in appropriate window mats and glazed with non-abrasive and non-static materials.

Another type of media used for fine drawings includes metal points on coated paper. The metal in the media can oxidize, causing a change in color. For example, a silver point drawing may become tarnished to black, or copper point to green. This may cause a piece to be misidentified. Silver point can be reconverted to its original appearance by exposure to hydrogen peroxide.

Ink, a term originally derived from encaustic by way of "inchiostro"(7) has often been used as a writing, painting and printing medium, although it is usually applied in thin washes rather than thick impasto. Ink traditionally has contained binders of oil, glue, gums, resins, and waxes mixed with pigments or dyes, particularly in modern "printer's ink". Some modern inks, developed for gravure, contain acrylics.(8) Inks can be both friable and soluble, especially as they age, leading to flaking and smudging. Iron gall ink has special problems owing to its acidity (from the oxidation of its iron component), which can in severe cases cause it to eat through the paper support. This can cause both loss of legibility because of strike-through, or actual loss of paper. Modern inks, and especially felt-tips, can be fugitive, fading in light. They also tend to be highly soluble. Inks low in carbon, like bistre, become invisible when examined under infrared illumination.

Painting Media: Ink can also be used as a painting media if applied in a wash of solvent. Painting media can be categorized in several ways, based on the composition of colorants and binders, such as tempera, gouache, watercolor, oil and acrylic. For example, gouache differs from water color in that it is an opaque medium, whereas water color is transparent. In watercolor the white or highlights come from the background paper, but in qouache the white is applied as a pigment. Gouache is sometimes used for impasto effects and this extra thickness causes a major problem with gouache media. It can crack, scratch, rub, abrade, etc. Some of these same problems may occur with tempera and acrylics. The above media, except for acrylics, can also be soluble in water. Oil paint is occasionally used on paper, and the problem here is twofold. The oil paint layer may be stronger than the paper and has a different expansion and contraction rate, and it can actually cause the paper to become acidic and brittle. Some examples of painting media commonly found on paper are described below.

Tempera is a generic term for any aqueous media that "tempers" or binds pigment with egg, glue, gum, or starch. Egg tempera, used primarily between the 10th and 15th centuries (when it replaced encaustic until superseded by oil paint) regained popularity in the 19th century. Egg tempera consists primarily of egg yolk, which is a natural emulsion containing a drying oil that can take up to a year to dry. It is not very flexible and can crack if thickly applied. Egg emulsified with oil is also used in tempera. Glue temperas use animal products such as casein (milk) and gelatin (skin, bones) and may have glycerine added to reduce cracking and formalin to reduce water solubility. Gum temperas use plant products (sap) and tend to be brittle if applied thickly. Gum arabic, used for tempera (emulsified with drying oils), gouache (made flexible with honey, sugar or glycerine) and watercolor, may require a preservative (halogenated or chlorinated phenols, boric acid, or sodium benzoate) and may be emulsified with oils and resins and mixed with other aqueous media. Starch, also derived from plants, can be used as a base for tempera emulsions. Egg-oil emulsions and casein temperas comprise most commercially produced temperas today since upon aging to a matt or semi-matt appearance they become insoluble in water. Those with oil emulsions can be thick and flexible, although they can develop hairline cracking and discolor with age. The use of temper was supplanted by gouache between the 16th and 18th centuries for illuminated manuscripts and miniatures.

Gouache, a generic term possibly derived from "gouazzo" or painting with glue size, typically has a gum arabic (acacia) or dextrin (starch) binder; a filler or white pigment to provide body and highlights, and a matt appearance upon drying. Gouache traditionally is susceptible to surface marring or cracking if applied thickly, and remains water soluble, unless as in modern times acrylic is added to make it abrasion and water resistant. Gouache is often confused with watercolor.

Watercolor differs from gouache in composition (having no white filler for body or highlights), in appearance (applied as a thin wash), and properties (less solubility and cracking after drying). Watercolor became established in the 18th century, used to illuminate books and manuscripts where the fugitive nature of such a lean medium would be protected. However, in the 19th century moist or semi-moist watercolor was made by adding glycerine, replacing sugar or honey which were added to improve flexibility and reduce cracking of cakes of watercolors; ox gall or other surfactant wetting agents may be added to reduce surface tension and improve flow. Student grade watercolors may contain dextrin rather than gum arabic and may have fillers. While watercolor remains soluble, often the appearance of a thin wash may not change since fine pigments penetrate and lodge within paper supports. Highlights are created by the reflection of the paper.(9)

Printing Media: Paint and ink have traditionally been used as print media. The categories of prints are based on in how the media is applied. Printing is a transfer process; media is transferred from one substrate to another substrate. The transfer methods vary. There are several major categories of prints: relief, intaglio, planographic, stencil, and photomechanical.

Relief prints are made by carving away areas of a printing block, usually wooden, to leave raised areas that carry the ink. When the block is placed in contact with a piece of paper and pressed or rubbed, the ink is pressed into the paper, sometimes actually indenting or impressing the paper slightly. This is especially apparent in Japanese woodblock prints or in letterpress prints found in early broadsides and newspapers. The major problem with relief prints is that this distinct impression around the inked areas, evidence of relief techniques, could be flatten or lost if improperly cared for or treated.

Intaglio prints are made by incising a plate, usually metal, by any of several processes. The incisions are filled with ink, and the plate is wipe so that the surface is clean. The plate is then inverted onto a damp piece of paper and run through a press to force ink to sit on top of the paper. As a result, there is an ink build up on top of the paper, and a creased, stretched edge around the image edge known as a plate mark. The raised ink is sensitive to abrasion, and the plate mark may be weakened or flatten. Occasionally the platemark is even cut down or off by insensitive collectors or framers who aim for a better fit in an album or frame. The plate mark is one bit of evidence for the authenticity of an intaglio (although they can be forged as well) and so it should never be cut down. When matting, the platemark should always be displayed within the window of the overmat to expose all that the artist included in his design. Examples of intaglio prints are engravings, etchings, aquatint, drypoint, and mezzotints. Hand-colored prints, glazed prints or Chine colles can be particularly sensitive to fading from light or to surface marring or planar distortion from scratches, changing relative humidity, etc.

Planographic prints, usually monotypes or lithographs, are created by placing a flat substrate, such as litho stone or piece of glass, with an inked design coating the surface, against a piece of paper and exerting pressure. This is characterized by having a virtually flat plane of both ink and paper with only the slightest possible expansion of the paper corresponding to the area of the inked surface. This technique is often used to imitate other media such as drawings, etc. These prints are common and relatively durable, and they pose relatively few problems for housing, storage, display and treatment unless handcolored or glazed. One exception to this is the special case of monotypes. The image is drawn directly on the planographic plate, which can then be printed only once, after which the bulk of the medium is completely transferred. Different types of media can be used, so these prints may have problems arising from different solubilities.

The stencil process involves allowing ink or paint to come in contact with only the design areas of the paper by essentially blocking the negative areas of the paper in a variety of ways. The ink is brushed or squeezed onto the paper around the negative space or through a blocked screen. Edges of image color often have little pinholes from burst air bubbles in squeezed paint.

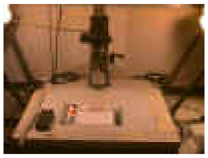
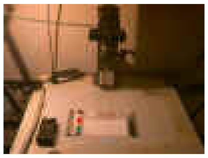
Photomechanical prints are distinguished from "fine arts" prints in several ways. Fine arts prints are hand-pulled in limited editions since the quality of printed image eventually changes as printing plates wear down. Photomechanical prints can be mass-produced without any change to the image because they are made by transfer of an image to a machine by a photographic process before printing. The ink used in a photomechanical is usually not water soluble and tends to be fairly durable, and there are seldom any hand applied coloring or glazes which might be sensitive. Consequently, photomechanicals are not usually inherently fragile unless made of ground wood pulp, and not inherently complicated to house, display or treat. The photoelectric process is that used to make photocopies both colored and non-colored. These prints should never be in contact with vinyl as the plasticizers can solubilize their media.

Scientific Analysis

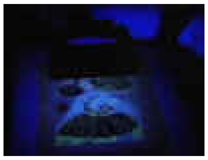
Determining the materials and techniques of objects may require not only stylistic and historical analysis, but also scientific analysis (Table 2). There are many ways to categorize scientific analysis of objects. Objects can be characterized qualitatively and/or quantitatively by using destructive or non-destructive chemical or physical analysis of formation techniques or furnish materials (both organic and inorganic). Qualitative analysis reveals what materials (elements or compounds) are present. Quantitative analysis measures how much of the elements or compounds are present. The quantity can be measured numerically and the numbers can be organized into tables or graphs. Destructive analysis implies that a sample (removed from an object) is destroyed in the process of analysis, as oppose to non-destructive analysis, where the sample (either still on the object or even if removed from the object) is not destroyed but remains available for further testing. Chemical analysis measures an object's chemical properties, including composition or pH, whereas physical analysis measures physical properties such as gloss or strength. Organic analysis identifies the carbon compounds (like hydrocarbons) derived from formerly living organisms, such as plants for paper or petroleum products for synthetic adhesives; inorganic analysis identifies elements and compounds derived from minerals (like oxides of carbon). Scientific analytical techniques can fall into several broad categories:

- Illumination
- Radiography
- Magnification
- Elemental Analysis
- Property Measurements

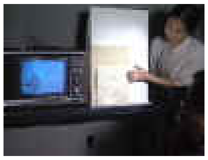
Illumination: An object's morphology (size, shape, texture) or optical properties (color, gloss, etc.) can be revealed through different wavelengths of light. The appearance of objects changes depending on the type of examination used. Wavelengths of light can illuminate, radiate, and irradiate objects. For example, light covered by red or yellow filters can reveal obscured writing under stains or in shadows. Monochrome sodium arc lamps suppress chromatic aberrations in order to penetrate glazes or overlayers to reveal signatures.

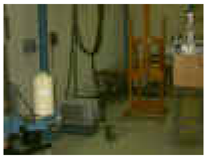
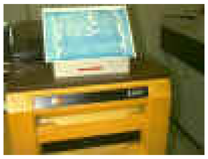
Visible light, the range that we see normally, shows different things about an object depending on whether it is aimed at the object from a spectral, raking or transmitted angle or direction. Spectral illumination, aimed directly (or spectrally) at objects shows us their color, shape and size, and reveals the presence of surface coatings or gloss. Raking light passes across the surface of the paper and dramatically reveals paper and media techniques and texture, and damages to the surface of the paper support (like cockling) and media (like flaking binder). Transmitted light, penetrating through paper, can show mold characteristics and watermarks, as well as tears or repairs. It can also provide other information about the type of mold on which the paper was cast, such as whether it was of a laid and chain type or wove type. By showing variations in densities, it displays fiber distribution, which indicates how the mold was move about during casting, and may also reveal damages and repairs not otherwise apparent.

Ultraviolet light, or "black light", reveals changes in elemental composition on the surface of objects because it causes specific fluorescence in materials depending on composition and age. Retouching, overpainting, varnishes, adhesives, and certain types of deterioration that might be invisible to the naked eye, like mold damage, can be detected and identified. UV fluorescence can sometimes make erased ink visible, can indicate overpainting or retouching, and can help identify different types of stains. For example, oil stains fluoresce orange, wax or starch can be bluish, or unsized paper deep purple. Different types of mold stains fluoresce differently, so even the kind of mold attack might be identified. Often mold attack is apparent in UV fluorescence even when it is completely invisible in normal light.



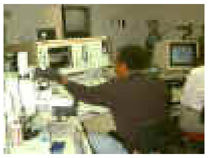
Infrared reflectography reveals carbon containing materials and otherwise "invisible" medium. Carbon media hidden under retouching, dirt, or other media can be seen, revealing underdrawings or pentimenti (literally changes in thought), or render other media invisible, such as bistre inks. Infrared illumination is especially useful with some drawing media. It can reveal covered signatures, or erased pencil and ink, or abraded or faded drawings. It can even penetrate paint layers to show primatura, or preliminary drawings.

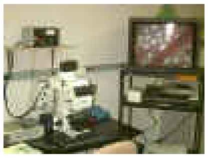
Radiography: Radiography, using X-rays or more sensitive beta- and xero-rays, reveals changes in elemental density, so that the physical structure of an object may be articulated to show different layers, additions, elements, etc. For beta radiography, the paper object is placed between a radioactive plate and a piece of film for about 30 minutes. The film is then developed and produces a negative similar to an x-ray. This can provide documentation of watermarks, mold characteristics and other relative densities of the paper. Xero-radiography is more powerful for denser papers and can sometimes reveal layers of papers.

Magnification: In addition to illumination, magnification is a useful and relatively simple means of examining an object. A magnifying glass can often help to identify inclusions in paper or the type of media. However, sometimes much higher magnification is required.

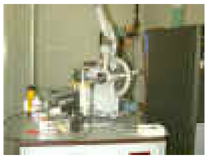
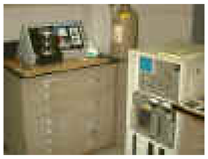
Stereoscopic microscopes equipped with cool temperature fiber optic raking light and ring can clarify the nature of media by revealing the size and shape of particles, the location of the media (whether it rests above, on top of or within the surface fibers), the layers of media or coatings, the type of deterioration (such as live mold), and the extent of damage, retouching or repairs.



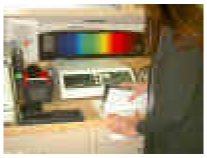
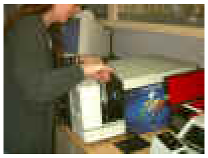
A Scanning Electron Microscope (SEM) provides a highly magnified view thousands of times the size of the sample and at a great depth field, to aid in morphological and topographical analysis of the sample.



A stage microscope with polarized light can magnify samples more than 100 times. Special features of this type of microscope can aid in the identification of an unknown component not only by magnifying their features, but also by allowing measurement of the optical properties of crystals, such as refractive index, extinction, and birefrengence. When carefully selected, samples may provide information which is not only approximately qualitative (i.e. what is present), but also quantitative (i.e. how much is present). Thin sections of objects can also be more closely examined, and layers identified, by this technique. Often a stage microscope is used in conjunction with microchemical tests. For this, the sample is exposed to various chemical reagents or solutions which have a known reaction with specific materials. For instance, identification of fiber types can be further confirm by noting the colors they turn when exposed to certain staining solutions.

Elemental Analysis: There are many forms of qualitative and quantitative instrumental analytical devices for identifying both organic and inorganic element, such as SEM elemental dispersive spectroscopy (EDS), Fourier-Transform-IR spectroscopy (FT-IR), Gas Chromatograph Mass Spectroscopy (GCMS), Thin-Layer Chromotography (TLC), X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF). Following various means of interacting with elements, a measurement or graph is created that serves as a fingerprint of the unknown component to be matched up with that of a known material.

Properties Measurements: The chemical and physical properties of materials change upon exposure to oxidative, hydrolytic or mechanical forces. Properties that can be measured and characterized include color, gloss, opacity, strength, acidity and degree of polymerization, among other things. Depending on the history of exposure or use of materials, such changes may be predictable, or they may be accelerated or anomalous. For example, the rates of deterioration from thermal or photo oxidation can be extrapolated from artificial aging studies using aging ovens and weather-o-meters.

Dating a paper object conclusively is next to impossible. There are several techniques for dating organic materials, such as radiocarbon dating, dendrochronolgy, sulfur dating, fluorine content, uranium content, nitrogen loss and amino acid racemization, but none of these techniques is particularly applicable to paper. As indicated at the start of this section, the best results can come from collaborative curatorial efforts.

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ENDNOTES:

1. For literature on these cases, see Rendell.

For the Hughes "autobiography", see Fay.

For Hitler's "diaries", see Werthmann.

For the Mormon fakes, see Naifeh.

2. For analytical techniques, see Newman.

3. For literature on stylistic analysis, see Konrad Oberhuber; Rendell.

4. For information on the history of paper making, see Dard Hunter; John Krill.

5. To recap: what one should know about a paper support in order to ascertain its quality or presence of inherent vice which is or may be a problem:

- o the fiber direction - it influences curl, strain
- o whether the fibers are long or short -influences fold endurance, strength
- o whether the paper has been bleached -influences strength and color
- o whether the paper is acid -migrates to other items; discolors
- o whether it has many impurities -sensitive to humidity & light
- o whether it is coated or not -makes it sensitive to moisture

6. For information on the history of media, see the following footnotes.

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