4. Support Problems

This section presents issues in the conservation treatment, storage, and/or exhibition of paper (or other) supports. These issues may relate to inherent properties of the support fibers, support manufacture, and fabrication of the object including additives, or changes in the support resulting from natural aging processes, environmental and handling conditions, or conservation treatment.

4.1 Purpose

To outline potential problems of paper supports and related materials which may influence the course of conservation treatments, storage, and exhibition of these materials, and suggest treatment approaches.

4.2 Factors to Consider

4.2.1 Inherent Physical Characteristics of Paper

Physical and chemical characteristics determine how successfully a support will respond to exhibition and/or conservation treatments and the degree to which they may be applied.

A. **Fiber Type**: Most paper fibers are composed of cellulose, the major structural component, and may contain associated materials such as hemicelluloses, lignins, etc. Fibers for papermaking are obtained directly from the plant or are derived from textile rags and cuttings. Sources include seed hairs (cotton), bast fibers (flax, hemp, jute, ramie, paper mulberry), wood (soft coniferous and hard broad-leaved trees), grasses (straw, bagasse, bamboo stalks), and leaf fibers (esparto, manila, sisal). (See **4.4.1 Fiber Type.**)

With experience and testing, the conservator can judge approximate fiber content and anticipate the success of treatments. Exact fiber identification may not be necessary before treatment, though approximate fiber identification may be reached after considering factors such as condition, context, and dating.

B. **Color** (See also **4.4.2 F. Colored Papers.**)

Color of paper has two aspects: the original, intended color as produced and the actual color which results from aging, etc. There is a subjective element in estimating the original color which may be aided by clues. Protected edges or inner surfaces may preserve a color closer to its original. Artists' use of white media or white highlights on the bare paper may suggest that original paper color was not white. If the highlighting is an alkaline material such as calcium carbonate, this substance may protect and preserve the original color which has faded or decolorized in the reserve areas. Sometimes original support color is evident on the verso behind opaque black washes which have shielded the paper from light damage.(KN) Sometimes colored corrective media can provide a clue to the original color of the sheet.(AM) Other guides could also be used to determine the original color of the paper. Paper sample books which have naturally aged papers protected from light and atmospheric pollutants can provide comparative material. (Especially for the 20th century, many comparative examples will exist for artists' papers and for multiples like prints.[KDB])

1. Original color is determined by:

   a. Natural tone of the fibers. There are differences among the different types of fibers (e.g., cotton and esparto) and also among the various qualities of the same fiber in their original condition. Even wood pulp fibers, the most regular of all supplies when obtained from the same source, will vary in color (Clapperton 1929, 121). Hemp is generally a darker color than cotton or flax; this partly explains its use in coarser papers. Wood pulp fibers are also darker than cotton or flax.

   b. Processing. Natural tone may also result from the processing of the fibers. In the processing of uncolored rags, fermentation can result in the yellowing of fibers; a yellow cast (creamy tint) distinguishes the finished sheet. This color, nonetheless, is its original color. For some old papers, lime-water soakings of the rags used in papermaking gave them a calcium boost which made them white.(SRA)

   c. Water purity. Impurities, such as iron and copper in the water used in papermaking, can alter color, making paper yellow. A high calcium content in the water can also whiten paper.

   d. Deliberate whitening/lightening of pulp using chemical bleaches.

   e. Additives to pulp or formed sheet (sizing, fillers, optical brighteners, dyes and pigments). For example, a yellowish cast can be imparted by a gelatin sizing.

2. Actual color of the artifact may be a result of darkening or lightening, or tonal shift from chemical changes caused by aging, mishandling, mold, exposure to light, or conservation treatment. For example, discoloration of size can occur through degradation produced by sulfuric acid, a by-product of

alum in the size. Conservation treatments may attempt to correct the above changes where there is evidence of instability or degradation. However, it may not be possible to return to the original color with conservation treatment. One may have to accept some changes due to aging or due to inherent components of paper. The object's integrity and its specific needs should give direction to conservation treatments.

C. Weight

1. Weight is determined by thickness and density of the sheet and additives present. Paper made by machine today has a definite basis weight (Browning 1977, 16).

2. Weight may be altered by the removal of soluble or reactive additives or other inherent components (i.e., lignin, acid products, fillers, starch, optical brighteners, etc.) during treatment. A change of weight is not usually thought of as a significant factor in conservation treatment.

D. Thickness

1. Thickness is determined by the depth of fibers applied to the mold or web screen, lamination of wet or dry sheets, and by pressing/burnishing of sheets. Paper made by machine today has a standardized range of thicknesses (or caliper).

2. Thickness may be altered by swelling of fibers by water or alkaline solutions during aqueous treatment and/or extreme pressure during flattening. Lack of restraint during drying can result in a more porous, swollen sheet.(AD)

E. Strength

The strength of a paper sheet is determined by the strength of the individual fibers (which depends on fiber type and quality), and on the strength of the interaction between the individual fibers (which depends on fiber type and quality and fiber treatment during manufacture). According to Browning (1977, 16) "The bonds between fibers arise from the hydrogen bonding that occurs between hydroxyl groups on the surfaces of fibers which are physically in contact."

1. Strength is determined by:

   a. The type and degree of beating during the preparation of the pulp helps to determine the nature of fiber interaction.

b. The manufacturing method of a paper sheet will determine the direction of the fibers: unidirectional handmade and machine made papers tear easily in the grain direction.

c. The presence and type of sizing agents, coatings and loadings, etc., also effect support strength. For example, beater sizing will increase the overall strength of a sheet, whereas surface sizing will allow the core of the sheet to remain flexible while its surface is made firm (e.g., a requirement for papers used in modern lithographic printing processes which need a surface resistant to tacky-ink pick-up). Loadings will contribute no strength of their own; in fact, they interfere with the interaction of the fiber network and may thus decrease the overall strength of the sheet. Coatings and other treatments will also modify the strength of the paper.

2. Strength may be altered by chemical embrittlement due to aging, contact with acidic materials, aqueous treatment in poor quality water, highly alkaline treatment, or inappropriate bleaching methods, mechanical damage, and removal of sizes or coatings.

3. Strength may be altered from washing, addition of sizes, and other aqueous treatments. Washing in suitable water quality removes impurities which interrupt fiber-to-fiber bonding.

F. **Absorbency**

Absorbency is the degree of receptivity of a material to liquids or gasses. Paper responds to the relative humidity or wetness/dryness of its environment by absorbing or giving up moisture. This effect may or may not be uniform in all directions, depending in part upon the process by which the paper was manufactured (Roberts and Etherington 1982, 3).

1. Absorbency is influenced by the hygroscopic nature of cellulose, porosity of the paper structure, degree of maceration of the fibers, method of sheet formation, sheet thickness, sizing, sheet finishing, and the paper's state of preservation/deterioration.

2. Absorbency may be reduced by the addition of transparentizing agents, coatings, or sizing (gelatin, glue, starch, gums, resins, or cellulose ethers). Sizing is added specifically to improve resistance to moisture penetration. Waterleaf (blotting) paper has no sizing or coating; fluid

media will bleed into it. The addition of alum to gelatin produces a harder, less water-soluble size upon drying. Absorbency can be reduced by removal of soluble deterioration products.(AM)

3. Absorbency may be increased by the removal of sizing or transparentizing agents during treatment. In contrast, sizing may be reactivated during float washing (see Cohn 1982). Solvent treatments, such as the use of ethanol as a wetting agent, may increase the rate of absorbency. Very deteriorated paper may wet out immediately due to cumulative aging properties such as the breakdown of sizing or wet out unevenly due to uneven deterioration. Often the outside edges of a sheet wet out more easily and mold damage, which deteriorates size, can create uneven wetting patterns.(KDB)

G. **Dimensional Stability**

Dimensional stability is the property of paper which relates to the consistency of its dimensions (Roberts and Etherington 1982, 77).

1. Dimensional stability is a function of:

    a. The absorbency of the particular fiber type. This property derives mainly from the nature of the specific type of chain molecule forming the fiber structure. If the molecules are hydrophilic (e.g., cotton) then the fiber will absorb moisture; if hydrophobic (e.g., some synthetics), the fiber will not. Absorption also depends on the ease of accessibility of the water molecules to all parts of the fiber i.e., the presence of crystalline versus amorphous areas. The more highly crystalline the structure, the less penetrable it will be. The hygro-expansivity of fibers depends on their water content. Dimensional changes in fibers (for example, a 1% length and 20% diameter change) will lead to dimensional changes in paper. Thus, because of their different nature and proportions, linen fibers (and hence sheets made of linen fibers) will react differently than ground wood fibers. Japanese papers have a wide variety of characteristics that influence dimensional stability (see AIC/BPG/PCC **29. Lining** 1988, 7).

    b. Degree of hydration of the fibers. The degree of hydration is increased by extensive beating.

    c. Length of the individual fibers and orientation of the fibers in the paper sheet. Plant morphology is responsible for the fact that natural fibers generally swell more in their diameter than in their length. Fiber orientation in paper is determined by the method of sheet formation. In a machine made paper the majority of the fibers are aligned in one direction by mechanical vibration, whereas the fibers in a handmade paper are generally oriented in all directions during sheet formation. When the fibers lie mainly in one direction, the paper when exposed to moisture will noticeably move (expand/contract) perpendicular to the grain (i.e., fiber orientation). Degraded papers generally show less dramatic dimensional changes (AIC/BPG/PCC 29. **Lining** 1988, 4-5).

d. Thickness and density of the sheet.

e. Presence or absence of sizing. Waterleaf paper will expand significantly with moisture penetration. The presence of Aquapel sizing (alkyl ketene dimer) in some modern papers will limit water penetration and expansion or contraction characteristics.

f. Method of drying during manufacture.

g. Media application.

h. Presence of previous attachments or their adhesive residues.

2. Dimensional stability of a support may be altered by compaction of the fibers in some areas of the sheet (printing pressure – typeset, intaglio, woodblock, etc.), or conservation treatment – mending, lining, drying methods, etc.

H. Pliability

Pliability is the degree to which paper can "give" (its flexibility and extendibility) without fiber breakage when bent. Pliability allows paper to be compressed by and retain the shape of a printing plate, drawing point, embossing tool, etc.

1. Pliability is determined by each fiber type's unique arrangement of fibrils. (For example, the helical winding of sheets of fibrils around an axis gives the cotton fiber superior pliability [Cumberbirch 1974, 147].) Pliability is also the result of the treatment of the fiber during preparation and manufacture.

2. Pliability may be altered (usually increased) by the presence of moisture in the environment, moisture content of the object at

a given RH, sizing, or washing out impurities that interrupt fiber-to-fiber bonding. Washing alone may change prior "restraint" characteristics or prior drying characteristics.(AD) Improving pliability may be a reason to proceed with washing.

3. Pliability may be altered (usually decreased) by deterioration of components of the paper on aging or poorly chosen conservation treatments (see **4.2.1 E. Strength**).

I. Surface Texture

Factors responsible for texture vary with the type, quality, date, and place of manufacture. Paper has a wide range of typical textures. For example, the typical texture of fifteenth and early sixteenth century German paper apparently resulted from the fact that the newly formed sheets received no further pressing after the initial pressing between felts, which left the texture of the felts visible (Robison 1977, 7). The paper texture of early woodcuts seems more evident because rougher, heavier papers tended to be used, etc. whereas intaglio prints are characterized by an embossed platemark and an enhanced smoothness, even silkiness, created within the plate area during printing (Robison 1977, 8). See also **4.4.2 O. Watercolor Papers.**

1. Surface texture depends on fiber type, preparation, and finishing. Handmade papers' surface characteristics are determined by pulp preparation, mold design, and the texture of felts used during drying and pressing. Change in texture may be accomplished with further pressing, burnishing, glazing, etc. For machine made papers the nature of sheet formation, drying, pressing, or calendering determines surface texture. In general, the addition of sizes, fillers, and coatings increases smoothness by filling in the paper pores. With some modern machine made artists' papers, grain finishes are made by the application of special felts that impart a handmade look.

2. Surface texture may be altered by media, mechanical damage (tears, burns, creases, abrasions, stains), results of conservation treatments (aqueous treatments, alkaline treatments, lining and/or flattening methods, use of suction table, blistering during bleaching, burnishing during surface cleaning, etc.), or as the result of mounting/matting for display (overall mounting, dry mounting, etc.). For example, if the original sizing is removed in alkaline washing, the surface sheen of the paper may be altered and the fibers softened and loosened so that texture may be further modified upon drying.

J. Transparency, Translucency, or Opacity

1. Transparency and translucency in paper depend on the comparative absence of light reflecting or absorbing facets on or in the fibers, minerals, or other components in/of paper. Treatments which cause fibers to pack more closely together and which eliminate or fill up air spaces, may produce transparency or translucency by allowing light rays to pass through the sheet relatively unbroken or unreflected; such treatments include fiber treatment during manufacture (fibrillation – extensive beating gives a more translucent sheet), the addition of starches, sizes, etc., and finish. (A more transparent paper results from treatment with iron rolls than with the super-calender because the former causes greater compression and reduction in bulk which enhances transparency in comparison with those rolled with the latter.) Coatings such as waxes, resins, and/or varnishes may produce a more transparent sheet.

2. Opacity may be produced by limited beating and pressing of paper which gives it bulk and a rougher surface, and by the addition of starches, mineral fillers, and/or by colors and certain dyes (Clapperton 1929, 306).

3. An undesirable transparentizing effect may result from aged pressure-sensitive tapes, oil-based stains, and some gummed taped adhesives.

4. Translucency or transparency may be decreased by the removal of transparentizing agents during treatment and by lining.

4.2.2 Chemical Stability

A. Sources of Acidity

One of the factors in the deterioration of paper is the presence of acidic components resulting from the degradation of the cellulose fiber or additives in paper manufacture. The anhydroglucose units in cellulose are joined by acetal linkages that are sensitive to acid hydrolysis.

1. Fiber type and quality. For example, the fibers of ground wood papers contain lignin which is chemically unstable, especially when exposed to light, and which breaks down to produce acidic components that attack the cellulose. Newsprint may be as much as 80% or more ground wood pulp. This

accounts for its inferior strength and color stability. (See **4.4.2 B. Mechanical Wood Pulp Papers.**)

2. Sizing, such as alum-rosin and gelatin with alum added, may become acidic. Gelatin is stable at a pH just below neutral. Alum is an agent added to both gelatin and rosin sizing. Alum was used increasingly by papermakers as early as the 1600s to aid in sheet formation. A by-product of the degradation of the alum used in the size is sulfuric acid. If excess alum is present it will contribute to the build-up of acidity in the sheet.

3. Oxidation agents. Light, heat, and pollution provide agents necessary for chemical reactions within paper which increase the free hydrogen ion (H^+) supply, therefore contributing to acid hydrolysis. Ozone is an oxidizing agent, but SO_2 and nitrous oxides promote acid hydrolysis. Nitrous oxides also promote ozone formation.(LP)

4. Dyes or pigments: Certain colorants such as iron gall inks, and copper greens, can hasten degradation of cellulose. (See **4.2.1 E.**)

5. Coatings (i.e., gelatin, egg-white, varnishes, glues, etc. [see also **4.2.1 I-J**]).

6. Residues of bleaching agents will be found especially in low-grade rag (colored or dirty, worn rags that require bleaching) and non-rag pulps. Almost all early chemical bleaches contained chlorine residues, which often remained in the paper since they were difficult to remove with ordinary washing. Chlorine is highly reactive and can form hydrochloric acid when combined with moisture. This acid is also present in paper that has been bleached with chlorine as a restoration measure and inadequately rinsed in antichlors and water. Papers affected by chemical bleaching may be characterized by loss of strength and discoloration, either immediately or with time.

7. Residues of chemical pulping agents (See **4.4.2 C. Chemi-Mechanical and Semi-Mechanical Pulp Papers and D. Chemical Wood Pulp Papers.**)

8. Fillers (See **4.4.2 H. Loaded Papers**)

9. Other impurities

B. Sources of Alkalinity

Some sources of alkalinity include residues of chemical pulping agents, sizing, coatings, fillers, water used in the papermaking process, pigments, deacidification and alkaline bathing, and some bleaching treatments.

C. Heavy Metal Ions

Some transition metals, especially, copper (Cu), iron (Fe), cobalt (Co), manganese (Mn), and zinc (Zn), may catalyze the degradation of cellulose in the presence of oxygen or moisture (Shahani and Hengemihle 1986). These metals can be introduced into the paper from the fiber source (wood, linen, etc.) which may contain trace elements from the ground in which it was grown, or by the equipment, water and chemicals used in paper manufacture (see **4.2.3**) and by some conservation treatments. Their presence can cause problems in paper as it ages and is exposed to mold, high relative humidity, light, and pollution, and some conservation treatments (e.g., oxidative and reduction bleaching).

4.2.3 Sensitivity of Paper to Its Environment

The environment is one of the most important factors in the survival of works on paper. The major elements of the environment that affect paper's longevity are light, relative humidity, temperature, airborne pollutants, and housing materials.

A. Light

All wavelengths of light, including ultraviolet and infrared radiation, affect various components of paper (cellulose, hemicellulose, lignin, pigments and dyes, sizing, etc.). The mechanisms are complex (See Feller 1964). Ultraviolet radiation and the violet end of the visible spectrum can contribute the energy needed to initiate direct or indirect deteriorative chemical reactions in paper, especially when oxygen is present. These reactions also occur in the visible range. The results include color changes (fading, darkening) or actual structural breakdown of materials (Banks 1989, 80). The extent of photochemical deterioration depends upon the intensity of radiation, wavelength, and length of exposure.

B. Relative Humidity

Because paper is hygroscopic, changes in relative humidity (RH) affect the actual resultant moisture content of the paper (equilibrium moisture content or EMC). It is not feasible to routinely measure and control the actual EMC of individual works so ambient RH is measured and controlled instead (Banks 1989, 80).

1. High RH, in combination with warm temperatures, promotes the biological deterioration of paper, encouraging the growth of mold or fungi, foxing, and/or insect attack. High RH also causes dimensional change, planar distortion, breakdown of paper size, and loss of paper strength. Rate of acid hydrolysis reaction increases in high humidity conditions; this phenomenon becomes increasingly significant with high acid content collections.(LP)

2. Fluctuating moisture content generally causes stress to fibers as they alternately swell and contact. There is a lack of good information on the effects of cycling on both individual materials and composites; cycling RH may accelerate aging (Banks 1989, 81).

3. Extremely low RH can reduce the flexibility of paper and cause dehydration, shrinkage and embrittlement of the specific fibers. It is not yet known, however, if for long-term permanence the presence of a high EMC is not more damaging than an extremely low RH (e.g., desert conditions).(AS)

C. **Temperature**

The rate of chemical reaction doubles with a 10°C increase in temperature. Different papers have different activation energies, derived by the Arrhenius equation, which make their rates of chemical reaction extremely difficult to calculate. Lower temperatures will slow deterioration. Biodeterioration will also be reduced. Excessive heat causes yellowing, drying and embrittlement of paper and may cause an increase in biological activity. Temperature also has an indirect effect through its influence on RH and equilibrium moisture content.

D. **Airborne Pollutants**

Air pollution, largely from the burning of fossil fuels, contains acid forming components in the form of solid particles and gases.

1. Particulate matter (particles large enough to settle out and cause soiling); dust and oily grit may be acidic, soil paper, weaken it by abrasion, provide nutrients for mold and insects and may contain traces of metals (see **4.2.2 C. Heavy Metal Ions**). Fungal spores are also carried in airborne dust.

2. Smaller particulates may include "acid dust," comparable to "acid rain," which could cause chemical deterioration of organic materials such as paper (Banks 1989, 82).

3. Gaseous pollutants include gases (SO_2 and nitrous oxides which are a complex system of several nitrogen-based gases) that form acids in the presence of moisture and the oxidizing agent, ozone. These pollutants increase the acidity of materials that absorb them, thereby increasing their rate of acid hydrolysis and/or hastening their oxidation (Banks 1989, 80).

E. Housing Materials

1. Paper is a good absorber of many types of organic vapors and liquids when exposed to them. Acids are transmitted into the primary paper support from prolonged contact with acidic housing materials (wood, ground wood pulp paper and cardboard, unstable plastics, acidic adhesives) although, "apart from sulfuric acid, it is not known what the migrating acids in paper are....The chances of a solid migrating are less than for liquids, but gases can migrate very easily and aging organic materials produce a variety of volatile materials" (Daniels 1988, 95, 97). This acid will build-up over time and, like internally generated acidity, it will discolor, weaken and embrittle the paper support. Typical visible problems observed include matburn and discoloration from the transferred pattern of wood shingle, corrugated cardboard backing, newspaper clippings, etc., and overall darkening or edge darkening from poor quality boxes, folders, mats and/or frames. (See also Weidner 1967.)

2. Protection against air pollutants, transmitted acids, etc., is provided by housing/storing objects in neutral atmospheres, in direct contact with clean, acid-free materials (near or above-neutral and with constituents that ensure permanence), and by using adhesives which remain reversible upon drying and contain no impurities.

3. In showcases and other enclosures, natural or synthetic materials, unsealed woods, treated fabrics, formaldehyde, or other materials can injure by vapor or contact. Some materials that have been observed to cause problems include wood, resin-based paints or adhesives used in laminate boards, dyes and finishes used on textiles, adhesives used in construction, etc. (See Padfield 1982; Miles 1986; Ellis 1980).

4.2.4 Alteration of Paper Support upon Aging

A. Chemical Deterioration

1. Discoloration of cellulose.

2. Fading or color changes of dyes or pigments.

3. Yellowing and embrittlement from oxidation of resins, oils, or waxes used as sizes or transparentizing agents. This discoloration and embrittlement may be irreversible since removal of discolored component may drastically alter transparency or feel of sheet.

4. Embrittlement, due to shortening of polymer units (cellulose, hemi-cellulose and lignin) is caused by oxidation or depolymerization by hydrolysis; embrittlement of tranparentizing agents, sizings, or coatings; or presence or breakdown of other components of paper sheet.

5. Discoloration of sizing.

6. Stains, particularly foxing.

B. Physical Damage
Physical damage results from handling, accidents, poor quality storage and housing, including matting and framing. Natural physical weakening and embrittlement of some papers upon aging makes them more susceptible to physical damage.

4.2.5 Potential Alteration of Support During Handling

A. Chemical Deterioration
Stains, discoloration, oxidized finger prints.

B. Physical Damage
Tears, folds, creases, splits, holes, losses.

4.2.6 Potential Alteration of Support During Conservation Treatment

A. Chemical Deterioration

1. Change in pH: acidity increase, alkalinity resulting from neutralization or buffering.

2. Introduction of heavy metal ions due to wash water impurities.

3. Possible removal of ions due to "ion-hungry" wash water.

4. Oxidation of fibers (oxidative bleaching).

B. Physical Damage

1. Changes in optical/aesthetic qualities (color, luster, translucence, opacity, reflectance).

2. Mechanical changes to paper surface (abrasion, compacting, lifting of fibers, skinning, local or general flattening of texture, surface or interior "gritting" from crystallization of alkaline solutions, i.e., calcium carbonate).(AS)

3. Changes in local or general permeability to aqueous and non-aqueous solutions and in sensitivity to atmospheric humidity.

4. Alteration of sheet thickness by change in laminar structure (linings, backing removals, mends).

5. Change in flexibility.

6. Addition or removal of sizings, fixatives, coatings.

7. Change in dimensions from aqueous treatments.

4.2.7 Relationship of Media to Support
(See **3. Media Problems** 1985, 1.)

A. Media may discolor and/or degrade paper (e.g., highly acidic media like iron gall ink, verdigris and acidic collage materials; oil paint and oil binder of some printing inks).

B. Media may protect paper by buffering against acidity or forming physical barrier against light or acidic materials.

C. Degradation of support may physically endanger media (e.g., shrinkage, expansion, wrinkling, or mechanical damage of paper causing loss of media).

D. Degradation of support may chemically harm media (e.g., effect of acidic paper on pH-sensitive pigments in dry state or during aqueous treatment).

E. Change in color and tonal relationships of media and support due to discoloration of support (darkening, yellowing, bleaching, fading or color change of dyes and pigments, stains).

F. Compatibility of paper and media (e.g., toothed surface will trap powdery media like pastels and charcoal).

G. Compacting of paper due to pressure of printing techniques or resistance to moisture by media may cause local differences in absorbency of sheet and of dimensional response.

4.3 Materials and Equipment

See previously published editions of the Paper Conservation Catalog for materials and equipment for treatment of paper problems.

4.4 Treatment Variations: Support Types

4.4.1 Fiber Type

A. **Cotton Fibers, Linters and Rags**: Cotton textiles, made from long cotton seed hair fibers, were generally used as a fiber source for historic fine papers from about 1800. "Occidental papers from before 1800 which are described as 'rag' papers are mostly linen-based with hemp fibers" (Collings and Milner, 1984, 59). However, before 1800 cotton may occasionally be found in coarse papers such as brown wrapping paper. Paper made from cotton cuttings and rags was inherently strong and durable. The characteristic twisted corkscrew shape of the relatively thin-walled and wide-lumened cotton fibers produced bulk and opacity in paper as well as softness. Cotton fibers do not pack closely together in the formed sheet as flatter fibers do (Clapperton 1929, 3). In addition, the quality and previous history of cotton and other rags (their age, cleanliness, presence of other fibers, fillers, dyestuffs, etc.) directly influence the properties of the paper. For example, the cellulose in very degraded rags may have a low degree of polymerization and the resulting paper will be weaker and less permanent. When new, cotton fiber pulps are almost 100% pure cellulose; the papers produced from them can be of high strength and resistant to aging (Collings and Milner 1984, 61). The cotton fiber is difficult to fibrillate in the beating stage of papermaking because of its highly parallel fibril orientation. In general, the finished cotton fiber paper sheet will be less stiff and strong than a linen rag fiber sheet where fibrillation occurs readily (see **4.4.1 B. Flax/Linen**). Although the cotton fibers will not lie closely together because of their twisted configuration, in sheet formation on the mold or machine wire, they do become interlocked which adds strength, flexibility and bulk to the paper (Clapperton 1929, 3). Because textile rags are expensive and scarce, today, many fine rag papers are made from cotton linters, which have a shorter fiber length. Cotton linters are the fine, silty fibers which remain adhered to the cotton seed after ginning and are a mixture of long and short fibers. Papers made from cotton linters are characterized by softness, bulk, absorbency and, often, low strength.

B. **Flax/Linen** (Linum usitatissimum): Flax, a bast fiber, is essentially a textile fiber. For economic reasons flax fibers used in papermaking are generally in the processed form of linen rags and cuttings. Because flax is harvested for its fiber before extensive lignification develops, the lignin content is relatively low compared to other bast fibers. The fibers are separated from the woody matter by a selective biological method (fermentation), called retting. The relatively thick, straight walls and narrow lumen of flax makes it a stiffer and stronger fiber than cotton, which has a thinner cell wall and relatively wider lumen. When beaten during papermaking, the structure of the flax fiber allows it to splinter easily along its length, releasing the small fibrils. The fibrils interlock and impart great strength when the paper sheet is formed (Hills 1988, 54). The amount of fibrillation of the flax fibers is a function of the nature and amount of beating. The quality of the fibers and of the resulting sheet are subject to the same variables as cotton. Generally a linen fiber sheet will be stiffer and stronger than a sheet made from cotton which does not readily fibrillate. (See **4.4.1 A. Cotton Fibers, Linters and Rags.**)

After about 1800, supplies of cotton waste and rags increased, relative to linen, and rag papers from this period may contain both linen and cotton. Today linen fiber is seldom used alone for papermaking because of its relative scarcity and expense. Also its extreme 'wetness' in working renders it practically impossible to make strong, thick, or even medium-weight papers on a Fourdrinier machine (Clapperton 1929, 5). Its great value is in combination with cotton to stiffen and strengthen papers made with cotton fibers.

C. **Hemp** (cannabis sativa): Hemp is an Asiatic herb which yields a tough bast fiber when retted. Hemp fibers exhibit properties similar to those of linen and the two are difficult to distinguish by "ordinary" examination (Roberts and Etherington 1982, 131). For example, during stock preparation hemp fibers fibrillate well, though less readily than linen. Originally, the papermaker obtained hemp principally from rope, cordage, and textile sources. In Europe, hemp was used in papers to capitalize on fiber strength, pliability and durability; it was rarely bleached and almost never used alone. Hemp is generally of a lower grade than linen and is mainly used in coarser paper (Krill 1987, 13). The term "hemp" has also come to be used in a generic sense as fiber and is then proceeded by an adjective (e.g., Manila hemp, Sisal hemp are classified as leaf fibers, see **4.4.1 H. Leaf Fibers**).

D. **Jute**: A bast fiber was an important raw material for papermaking, especially in the mid-nineteenth century. The use of jute fibers in European papermaking was first described at the end of the eighteenth century (Hunter 1978, 394, 522). Its use has declined in recent decades, though Hunter (1978, 223) notes the presence of jute fibers in modern Indian papers. Jute is a lignified fiber and is coarse, rough, stiff, and brown in color. It cannot be satisfactorily bleached. Jute ropes, strings, bagging and other cuttings were used to make brown wrapping papers; little chemical treatment of the fibers was required because these papers were intended to be cheap and their color and coarseness were unimportant. Because of its high lignin content, paper made from jute darkens if exposed to light and atmospheric pollution.

E. **Ramie**: A bast fiber, also called China Grass or Rhea, ramie is cultivated in tropical countries. The fiber is removed from the woody stalks by a process of decortication which may include peeling, soaking, and/or scraping. The long fiber strands are then dried and bleached. Ramie fiber is white, lustrous and strong; it is durable, stiff and coarse, lacking in flexibility and cohesion. Ramie absorbs water readily. The cells' fibers are very long and thick walled (Cook 1984, 22-24). Ramie has been used since ancient times but only in modern times on a commercial scale for textiles and in papermaking.

F. **Straw**: Straw, a bast fiber, was a source of fibrous raw material for papermaking in ancient China (Hunter 1978, 375). Straw was not used in the West until the eighteenth century (cereal straw was used by Koops in his experimental papers around 1800). The use of cereal straw (wheat, barley, rye, oats, rice, etc.) for Western papermaking was commercialized in the U.S. before wood - ca. 1829 (Hunter 1978, 395). It was used, in particular, for printing papers, wallpaper, wrapping paper, and binders' board. Straw remained a major source of fibers in Europe and North America until the 1920s when the wood pulp industry was firmly established. It is still an important source of fiber in countries where grain is grown in sufficient quantities, where pulpwood supplies are scarce, and imported wood pulp is too expensive. Although, some countries, such as in the Orient, import pulp rather than use grain.

Bast cells are the principal sources of the fibers; they derive mainly from the pith of the stem. The good paper formation characteristics of straw fibers result from their relatively high ratio of average length to diameter. Wheat and rye are preferred; they produce stronger and stiffer papers than other straws. "Straw, when digested with caustic soda under pressure yields, if bleached, a white pulp paper, almost pure cellulose" (Hunter 1978, 395). The resulting fibers are fine, brittle and shorter than those obtained from wood. The short fibered paper produced from straw pulps has low tear strength and is often strengthened with an admixture of longer fibered stock. Today, bleached straw pulp yields fine writing and printing papers while unbleached straw pulp is used for boards, corrugating medium and packaging paper (Casey 1980, 525).

G. **Wood**: Papermaking fibers obtained from wood differ in appearance and properties depending on their source.

Softwood and hardwood trees, treated in different ways, give wood fibers suitable for making almost any kind of paper. Cotton fibers blend extremely well with fibers of chemical wood and useful papers of all types are made from a mixture of the two (Clapperton 1929, 96).

Mechanical wood pulp is raw wood ground with water into "sawdust"; no chemical treatment is undertaken to remove impurities (lignins, etc.). The fibers are short and brittle and are often joined in clumps by medullary rays. Mechanical wood pulps are used in newsprint, cheap printing papers, cheap colored boards, etc. **Chemical wood** pulp fibers are fairly long (length varies) although shorter than cotton or linen fibers. Chemical wood pulp fibers are wide relative to their length, flat, sometimes twisted, and their walls are usually "pitted" with small pores or holes. **Softwood fibers** are longer and stronger than hardwood fibers. Softwood fibers made into pulp by the Kraft or sulfate process "stand hard beating and become very 'wet' and make wonderfully strong wrapping bag and (other) papers" (Clapperton 1929, 5). **Hardwood fibers** resemble esparto in that they are short and fine, but they are much flatter and do not give such good bulk for the same finish and substance. They can give good printing papers when treated by the soda process. Today **chemi-mechanical** and **semi-mechanical** processes are also used. The former was introduced in the 1950s and the latter in the 1920s. Their advantages include the ability to use hardwoods and to bleach mechanical wood. Processes include the gentle use of chemicals followed by harsh mechanical or vice-versa. Under the microscope, pulps by these two processes appear more like chemical processed pulps than ground wood pulps (Britt 1970, 197-208).

Wood pulps made by the soda or sulfate process have better bulking qualities than sulfite pulp.

Wood fibers do not have the structure or the stability to produce extensive fibrillation; the fibers are "brushed in beating so that they are roughened by the partial fibrillation of their surfaces. Beating also clears fiber clusters" (Clapperton 1929, 98).

H. Leaf Fibers

1. **Esparto**: Leaf fibers from esparto, a coarse grass native to Southern Spain and North Africa, are short and fine, and are the smallest in diameter of the common papermaking fibers. Though very short, normally less than 3 mm in length with an average length of 1.5 mm, they have thick walls and can be beaten to give bulk and opacity to paper. For this reason they are found in "featherweight" printing papers characterized by a regular composition, close silky texture, and smooth uniform surface. Esparto paper is dimensionally stable; when esparto fibers are wetted they expand less than most other fibers. "This made (esparto) especially suitable for manufacturing high-quality printing papers....The short fiber length gave clarity to watermarks so it became popular for good writing papers too" (Hills 1988, 138). Esparto was also commonly used as a body paper for surface coating (Collings and Milner 1982/83, 26). It has a natural affinity for coating materials which gives it a superior surface for halftone reproductions (Roberts and Etherington 1982, 12). Because esparto fibers are so short, they impart no strength to papers. "For added strength esparto might be blended with a portion of longer, stronger fibers, such as rags or some wood pulps" (Hills 1988, 138). Esparto fibers were used primarily in Great Britain, where they were introduced in 1850 (Roberts and Etherington 1982, 93). They were first imported in quantity to the U.S. in the 1850s. Around 1900 imports of esparto diminished, in part because of the cost of transporting the grass or pulp but "largely due to the growing challenge of wood pulp...Today (it) has almost disappeared from the papermaking scene" (Hills 1988, 42). A number of pulp mills are in operation today in esparto growing areas. Because of the drastic chemical treatment required to separate esparto fibers from the non-fibrous plant elements and the severity of the bleaching process, the fiber, as prepared for papermaking, is severely degraded.

2. **Abaca or Manila hemp** (Musa textilis): Abaca, a type of plantain or banana native to the Philippines and found in Central and South America, yields fibers suitable for direct use in papermaking, particularly for papers where strength is required. The outer part of the leaf sheath yields the best fibers for papermaking. "The fibers range in length from 3 to 12 mm, the average being 6 mm....They taper very gradually towards the ends; the central canal is large and the fine cross-hatchings are numerous" (Roberts and Etherington 1982, 3).

3. **Sisal or Sisal hemp** (Agave sisalana or A. rigida): A West Indian plant whose leaves yield a fiber used in cord. Cord waste is used as a fiber source for some papers (Roberts and Etherington 1982, 237).

I. **Wool:** The use of woolen rags mixed with coarse linen for making brown paper in the 17th and mid-18th centuries is noted in Krill (1987, 14, 51).

J. **Fibers from Waste Paper/Recycled Paper:** Waste paper was used for several centuries for brown paper and board. "Matthias Koops tried to use it for making good quality paper around 1800" (Hills 1988, 208). Waste paper is an important "raw" material for paper mills today. As better ways developed for grading the waste, treating it to remove printing inks and colors, and cleaning it to remove dirt and waste, higher quality papers may be made.

Waste paper can vary widely in its characteristics (printed, filled, wood pulp, chemical pulp; wire staples, thread, glues, etc.). "Dry waste paper must be converted into a wet papermaking pulp, free from bundles of unseparated fibers and free from all impurities" (Hills 1988, 208). There are various ways to do this depending on the type of waste paper. Basically, the waste is churned up into a wet pulp mix, large impurities (plastic bags, paper clips) and sand are removed, and the waste disintegrated to separate the fibers. The fibers are subjected to further cleaning and, if necessary, de-inking operations and removal of fillers (such as clay). The pulp is pressed to extract dirty water and then stored. The fibers are combined later with clean water and virgin wood pulp to be made into paper in the usual way.

K. **Japanese Papermaking Fibers:** The three fibers generally used in Japan are kozo, mitsumata and gampi fibers; rice straw and bamboo are also traditional fibers in Japanese papermaking, their use, however, has been restricted. The term "rice paper" has been a misnomer for Japanese papers. See **4.4.1 O. Rice Paper Plant.**

Kozo, mitsumata and **gampi** are bast fibers obtained from the inner, white bark fibers of young mulberry trees. Despite their high price (Barrett 1979, 17), which is a result, in part, of the difficulties involved in getting the fiber from nature into a state of readiness for papermaking, these fibers have many advantages for papermaking. Even after beating, the fibers remain very long (3-12 mm) compared to 4 mm maximum for beaten wood pulp fibers. The fibers are very regular in thickness along their length; this regularity is responsible for the softness and sheen characteristic of Japanese papers. Strong, yet thin, papers can be produced because of the slender fiber shape, thin fiber walls and large amounts of attached, glue-like hemicelluloses.

Kozo (commonly "paper mulberry") fibers, used in Japan from the late eighth century, are the longest of the Japanese papermaking fibers – up to 12 mm in length. The finished paper sheet can be very strong and tough. Kozo is the most widely used of all the Japanese fibers and accounts for about 90% of the bast fiber produced in Japan for papermaking (Barrett 1979, 18). Traditionally kozo was the paper used for woodblock prints.

Mitsumata fibers are shorter than kozo (approximately 3 mm) and produce a shinier, slightly denser and crisper paper. Mitsumata was not used for papermaking in Japan until the late sixteenth century.

Gampi fibers average 4 mm in length. The plant, unlike kozo and mitsumata, grows too slowly for cultivation to be economical and the bark is harvested from the wild. Gampi was used in Japan beginning in the late eighth century. Gampi fibers are considered by some to produce the finest of the three papers in unmatched translucency, luster and character (Barrett 1979, 21). See also **4.4.3 A. Japanese Papers.**

L. **Papyrus**: Fiber quality is affected by the age of the plant when harvested, whether the plant is wild or cultivated, which portion of the stem is used, and the care taken in harvesting and manufacture (whether the prepared strips are sun bleached or not, the length of time fibers are soaked and the quality of the water used, amount of refinement of the fibers achieved by rolling them, whether or not strips used to make one sheet are cut from the same stem). (For more detail see Bell 1985, 29 and/or **4.4.6 A. Papyrus.**)

M. **Tapa**: "Tapa at its most refined state was white, cream or reddish brown and thin and fine textured. Since the intended use for the tapa product varied greatly, properties considered desirable were equally variable" (Bell 1985, 65).

Fiber quality (color, fineness/coarseness) is affected by climate, age and location within the plant from which fibers were taken, whether fibers are from a wild or cultivated source, care taken in cultivation, inherent fiber characteristics (length, width), and care taken in preparing the fibers (extent to which non-essential bark layers are removed, length of soaking before beating, whether lamination is by beating or pasting). (Bell 1985, 65 and **4.4.6 E. Tapa.**)

N. **Amate**: Amate is the term used in Central America to describe contemporary paper made from various kinds of mulberry trees.

"Amate" is also used to describe the trees in a very general way. The term is derived from the Nahuatl word "amatl" which described a pounded, bark "paper" made in the preconquest period in central America. Amatl "paper" has a very ancient tradition and is known to have been made at least as early as the first century. Conquest period literature describes this paper as well as "metl," a paper made from the majirey cactus (an agave plant, like the century plant cactus) (Sahagun 1963). The amatl paper was made from the inner bark of various mulberry tree varieties. The bark was soaked and then pounded with stones to make sheets of paper. Solutions such as limewater have been suggested as possible ancient soaking processes for this paper (Lenz 1961).

Newly made amate is also a pounded "paper," however, there are many different types produced and the quality varies. Some contemporary papermakers soak the fibers in alkaline solutions and/or bleaches before making the sheets. High quality papers are still made in the village of San Pablito, Mexico. (See Lenz 1961 or Bell 1985 for a description of the process.)

O. **Rice Paper Plant** (Tetrapanax papyriferus): The soft, spongy pith inside the larger branches or stems of the rice paper plant is used to make rice plant or pith "paper." The pith is removed from the branches of this shrub and then cut like wood veneer from a log (Bell 1985, 105). Fiber and paper quality will be affected by the precise source of the pith (branch or stem), the age of the plant, and the care taken in cutting and drying the pith (Bell 1985, 114).

The pith sheet is white, translucent, rather fragile and velvety smooth; it is made only in small sheets. See **4.4.6 D. Pith/Rice "Paper."**

4.4.2 Traditional Western Papers

A. Rag Papers

1. General Description

Rag papers were originally made from flax/linen rags and cuttings. From the late eighteenth century, cotton fibers were used or mixed with the flax fibers, also in the form of rags and processed cuttings. Rags were used because the value of the raw fibers for textiles put them beyond the means of papermakers. Raw fibers or new cloth made a paper that was too rigid and did not beat or fibrillate as well. Most rag papers today are made by adding cotton linters and using some fibers derived from fabric scraps. There are also "rag" cotton content papers which are as low as 25% cotton with mixtures of other fibers.

Only a few handmade paper mills use rag cuttings because there is no longer any collection of rags on a large-scale basis and the difficulty in obtaining pure cotton or linen rags. These mills use 100% natural-fiber fabric scraps obtained from textile mills and clothing factories and, more often, cotton linters. The increased brightness of paper produced during the latter years of the eighteenth century was a result, in part, of the increased use of "brighter" cotton fibers (Robison 1977, 49).

2. **Inherent Problems**

   a. The increasing mechanization of paper production had a compromising effect on paper quality. For example, the Hollander beater, introduced in the 1600s, chopped the fibers into shorter lengths. The early stampers, by contrast, rubbed, frayed, and spread (fibrillated) the long fibers. Paper made from fibers beaten in the Hollander is not considered to be as strong as that made from rags beaten in stampers; it is shorter fibered, less fibrillated and therefore may be weaker and less durable. The Dutch added more sizing which compensated for short fibers and gave strength.

   b. Handmade rag paper originally had a deckled edge with irregular folded edge flaps and edge cockles; in many cases the deckles have been trimmed. Early rag papers often show marks or fine, striated creases on the back from being draped over a rope to dry. These creases (called backmarks) are of historic interest. If the creases are removed during treatment, gaps may occur in design areas. Early rag papers may be a wide variety of off-white colors. This range of possible original colors should be considered in planning conservation treatments.

3. **Treatment Observations**
   Linen rag papers tend to retain papermaking and printing characteristics even after water treatments if carefully dried. Cotton rag papers do not retain the impression of printing after washing as well as linen papers. They do, however, retain impressions much better than papers made from cotton linters or wood pulp. It may be difficult to remove distortions from rag papers.(AD) As each sheet of handmade paper differs one from another, on should respect the integrity of the sheet and its subsequent use. Care should be taken to preserve the deckled edge and back marks.

B. Mechanical Wood Pulp Papers

1. General Description

(Ground wood pulp, thermo-mechanical pulp, refined-mechanical pulp; for more details on these individual processes see, for example, Hills 1988, 146.)

The structure of the debarked log (usually softwood) is broken down by applying intense mechanical action with grinders or refiners in the presence of water. The attraction of this method for papermaking mills is the high yield, and for consumers the inexpensive paper produced. Physically and chemically this paper is inferior; its fibers are short (average length is 3-4 mm), inflexible, and the finished sheet lacks cohesion. In addition, most of the lignin as well as the tannins, metallic salts, etc., remain in the paper. Wood pulp papers can be bleached to various degrees of whiteness, but diminish in brightness and discolor with age. The product is generally opaque, has good bulk, and good printability; it is used for newsprint, magazine and other printing grades.

2. Inherent Problems

"The presence of lignin is indicative of a chemically unstable paper. Lignin promotes brightness reversion (yellowing) and oxidation of the cellulose, contributes to total acidity and readily deteriorates photochemically.... Residual lignin in wood pulp is chemically altered from its native state. Often it is less stable, and breakdown creates byproducts that can accelerate the degradation of the cellulosic components of paper" (Young and Burgess 1989, 14-15; see also Lyall 1982, 72). This increase in the rate of the degradation of cellulose accelerates embrittlement. In the past, chemical pulp or other stronger fibered pulp has been added to newsprint to strengthen it so the web could be carried over the papermaking machine successfully. Recent developments have given mechanical pulp greater suppleness and bonding capacity using little, if any, reinforcing chemical pulp. Ground wood papers deteriorate rapidly, even when stored under the commonly accepted conditions of 68°F (20°C) at 50% RH. Mechanical ground wood pulp paper darkens (yellows) rapidly if exposed to light and atmospheric pollution.

3. Treatment Observations

a. The preservation of ground wood paper is a difficult problem. Until the mechanism of the degradative processes is understood it will be difficult to treat valuable items with confidence (Lyall 1982, 84). The long-term preservation of these papers may not be possible. Washing to remove acidity and degradation products, deacidification, proper housing, and limited exposure to light improve chemical stability of ground wood papers. In some collections, such as archival materials, changes in paper tone and texture which result from washing, deacidification and alkalization, are considered acceptable modifications since chemical stability is enhanced.

b. Bleaching (oxidative, reductive) usually lightens the color of darkened ground wood paper initially; however, darkening may occur later. (See **19. Bleaching** 1988, for details.) It may also unduly brighten a ground wood paper that was never bright white.(KN) Sun bleaching may not be appropriate for lignin-containing papers; may cause darkening or random spots.(NA)

c. Alkalization is a logical treatment for acidic ground wood papers, but it usually darkens, yellows, or grays the paper. The choice of alkalization treatment will have an effect on the paper color that results immediately after treatment. Some research (e.g., Lyall 1982, 83) suggests that alkalized paper will show less cumulative darkening after aging than non-alkalized paper so that both will end up about the same color. Choosing not to alkalize means that there will be no neutralizing of the inherent acidity. Washing before alkalizing will lighten the paper a great deal. Not only does this counteract the darkening associated with the alkalizing, but it also addresses the acidity.(CS) Some conservators feel that the alkaline buffer may get used up quickly in an acidic, reactive ground wood paper and that the benefit of alkalization may last only a few years.

d. Photochemically induced yellowing of ground wood pulp paper has been shown to be caused by light of wavelengths 355 to 400 nm (Lyall 1982, 84). To minimize yellowing, exhibit with UV filters at low light levels for a restricted period of time.

e. Encapsulation in polyester can preserve newsprint items and manuscripts which will be handled. If alkalization of the paper support is not part of the treatment before encapsulation, some conservators feel a sheet of alkaline paper should be inserted behind the object inside the polyester film. (See Shahani and Hengemible 1986 for considerations regarding encapsulation of modern papers and insertion of alkaline paper sheet.)

f. Housing in buffered board provides neutralization and improves chemical stability.

g. Reduction of temperature and maintenance of constant relative humidity may delay deterioration.

h. Material on ground wood paper (e.g., newspapers, periodicals, some books) can be microfilmed as an alternative to preserving the original. Microfilming is not an acceptable solution for works of art or manuscripts on ground wood pulp paper. Although microfilming, photography, or photocopying may be done to reduce the handling of archival materials.

i. New technologies may provide future preservation options.

C. Chemi-Mechanical and Semi-Mechanical Pulp Papers

1. General Description

(For more details on all these processes see, for example, Hills 1988, 153.)

In chemi-mechanical pulps the chips are treated very rapidly with nearly neutral sodium sulfite liquor before refining in a modification of the mechanical refiner process (85-95% yield). In semi-chemical pulps the wood chips receive a mild chemical treatment before being defibered in refiners (60-85% yield). These pulping operations remove only part of the lignin in wood fibers. Also see Hills (1988, 208) for the use of waste or recycled paper with wood pulp.

2. Inherent Problems

"Little specific information is available on the chemical effects of Neutral Sulfite Semi-Chemical (NSSC) residual lignin on paper permanence, but the stability of paper made from this type of pulp has been investigated...(A) calcium carbonate buffer may improve stability....In the absence of buffering, its stability may be no better than that of thermo-mechanical wood pulp" (Young and Burgess 1989, 15).

3. Treatment Observations

See **4.4.2 B. Mechanical Wood Pulp Papers.**

D. Chemical Wood Pulp Papers

1. General Description

(Soda, sulfate/kraft, sulfite processes–for more details see Hills 1988, 149.)

Economically viable processes for chemically converting wood into pulp for papermaking were not developed until the 1850s. The earliest was the soda process developed by Burgess and Watt in England in 1851; an American patent was secured in 1854. Using chemical wood pulp, a white paper suitable for printing could be made from wood. The sulfite process was developed in 1857 by the American, Benjamin Tilghman. Commercial production of this pulp began in 1887 at Cornwall, Ontario.

The two main chemical pulping processes today are the sulfate and the sulfite methods. Today, the term "sulfate" designates all paper pulps made by a process which uses sodium sulfate as its main chemical constituent. Exceptionally strong grades of paper and board are produced from unbleached softwood sulfate pulp. Hardwood sulfate pulps are also produced (Roberts and Etherington 1982, 254). One such paper is commonly referred to as kraft paper.

Sulfite pulp is usually made from softwoods. The wood is digested with a calcium (or other) acid sulfite cooking liquor. "Sulfite pulping is superior in the amount of lignin removed, and produces papermaking fibers that are white in color and can be bleached to higher whiteness with (fewer) chemicals than required for the sulfate process" (Roberts and Etherington 1982, 254). The paper made from sulfite pulp is not as strong as that made from sulfate.

Wood chips are heated under pressure with solutions of chemicals which dissolve out the cementing lignin. Then the chips are broken down into a fibrous slurry using very little mechanical force. Fibers contain very little lignin and paper can be made with high color stability and permanence thus meeting the need for a more durable and lasting paper from wood. Bleaching normally removes the last traces of discoloring lignin so the purest pulps contain only polysaccharides. This is achieved with some reduction in the polymer length and introduction of new chemical groups (e.g., aldehydes). This does not necessarily mean that the resulting paper will be less permanent.

2. **Inherent Problems**
Since there is a wide range of chemical wood pulp papers, inherent stability can vary.

Kraft paper is observed to deteriorate rapidly in some cases, but often is seen to have surprising strength, possibly through the introduction of borax, either to the paper itself or to the adhesive used in conjunction with contemporary kraft paper tapes.

3. **Treatment Observations**

E. **Alum-Rosin Sized Papers**

1. **General Description**
Alum ($K_2SO_4 \cdot Al_2(SO_4)_3 \cdot 24H_2O$) (Roberts and Etherington 1982, 9) has been used since the seventeenth century, and possibly earlier, as a hardener for gelatin sizing; as traditionally used, alum is weakly acidic in solution. The term alum originally referred to potash alum $KAl(SO_4)_3 \cdot 12H_20$. A new process, patented in 1807 and in common use by 1870, used aluminum sulfate (also called alum or papermakers' alum), which was cheaper, combined with rosin sizing. In it, aluminum resinate was precipitated onto the paper fibers in the pulp stage, leaving a residue of sodium sulfate and free sulfuric acid that led ultimately to the sheet's deterioration, particularly since the papermaker tends to "overdose with alum" (Roberts and Etherington 1982, 9). Rosin or modified rosins are used for the internal sizing of paper; addition of aluminum sulfate is required to link the negatively charged rosin soap to the negatively charged surfaces of the paper fibers. Thus, the alum renders the rosin insoluble so that it can impart water resistance to the paper. For the papermaking industry the alum-rosin sizing system is a reliable and cost effective means of sizing.

2. **Inherent Problems**

a. Deterioration of papers that are alum-sized vary greatly and is not always detectable in papers with alum added to gelatin.

b. "While alum is not a particularly strong acid, in the presence of certain other substances it can assume a greater strength....Excessive alum, in the form of aluminum sulfate, may react with chlorides present to form aluminum chloride ($AlCl_3$), which in the presence of moisture and heat, will form hydrochloric acid (HCl)..." (Roberts and Etherington 1982, 9).

c. Rosin is known to darken easily from exposure to light, elevated temperature and low relative humidity; this sizing appears to become quite brown if exposure is prolonged.

d. Alum-rosin size was often applied to very thick nineteenth century Whatman papers. Recently examined samples showed low surface pH, however, inherent strength still appeared good.(SB)

3. Treatment Observations

a. Reducing the darkening of the alum-rosin sizing is difficult. Until it is known how discoloration develops in this sizing and whether existing bleaching methods effectively prevent its recurrence, it is not known whether such treatments will provide anything other than short-term cosmetic effects (Perkinson 1986, 8).

b. Washing alone may significantly improve the darkened appearance of alum-rosin sized paper. If these papers are housed properly and exhibited with UV filtration, darkening may be reduced for some time.

c. Alum-Rosin sizing increases the light absorption of paper in the 330-440 nm region of the electromagnetic spectrum. Rosin-sized papers also yellow in natural light. This may be a contraindication to light bleaching.

d. If resizing is thought necessary, use of synthetic products or gelatin might be considered.

e. Some solvents affect sizing, cause tiding, and change absorbency of paper. This can be a problem, particularly with local treatments.(LP)

F. Colored Papers

1. General Description

Paper may be given an integral color through the choice of raw material or by mixing coloring matter into the pulp. Color may be added to the surface of the sheet during sizing or by sponging or brushing it on or by giving the sheet a colored ground or coating after manufacture.

4. Support Problems, page 30

a. Colored rags: Paper made from colored rags often has a mottled "color texture" since individual fibers or clumps of fibers from different rags are apparent. Old master drawings were frequently executed on blue paper because indigo was the only dye used for coloring rags, which would survive the fermentation, beating, etc. steps of the papermaking process (Long 1979, 68). Evidence for paper made from rags in a color other than blue, grey or brown is rare before 1796; rose colored papers are considered very rare.

b. Vat-dyed: Dyes or pigments are added at the beater, the size press, or the calender stacks; the latter two are surface coloring procedures. Greater color penetration is achieved at the size press, since the paper web is looser, than at the calender stacks. By the eighteenth century blue colorants were known to have been added to the vat (Cornely 1956, 44-60 referenced by Krill 1987, 61).

c. "Corrected white paper, a modern term, was paper which had a slight tint of blue, or occasionally red, added to it" (Krill 1987, 90). The whitener was added to correct the otherwise yellowish cast of the sheet. It became very popular in the eighteenth century (Krill 1987, 92) and continued in use (for example, charcoal drawing supports of Odilon Redon). Corrective whiteners include blue fibers and colorants such as indigo, smalt and Prussian blue. An advantage of indigo over smalt is that it spreads more evenly through the stock. The natural creamy tint of early modern rag paper was obtained by adding ultramarine blue. To obtain a creamier white, cochineal pink was added (Clapperton 1929, 122). The addition of red fibers has also been observed. Cheaper aniline dyes were also used but they may not be lightfast.

d. Optically brightened: A colorless dye absorbs light in the UV region of the spectrum and re-emits it as fluorescence in the visible region. Most optical brighteners are stilbene derivatives. They are often added in papermaking to "brighten" paper: their blue fluorescence complements the yellow cast of natural fibers and the eye perceives whiteness. Pigments, fillers, etc. are often added to optically brightened papers to produce further modifications of the yellow tint. Toners or brighteners, fillers, etc. are very common in poster papers (19th century to modern).(SRA)

e. Some pigments and dyes used to color paper include smalt (pieces of blue glass), ultramarine blue, logwood (produces black, blue, and gray), ochre and other earth pigments, cochineal, indigo, Prussian blue, turnsol, woad, etc. (see Labarre 1937 and Krill 1987 for further listings).

2. **Inherent Problems**

a. One of the most difficult tasks for a paper conservator is to determine the original color of the paper. Important elements to consider include aesthetic considerations, close examination of the paper, comparison with similar works, interaction of the media and paper, analysis of paper fibers, and paper colorants. (For a specific application involving these considerations see Perkinson 1986, 1.)

b. Unstable pigments and dyes may fade in light. Exposure to UV light over an extended period of time may change the structure of an optical brightener so that it no longer functions as a UV absorber and cause the paper to appear yellow.

3. **Treatment Observations**

a. Consequences of treatment procedures (washing, alkalization, stain removal, etc.) must be carefully considered. Unstable pigments (usually organic) and dyes may change color. For example, Prussian blue, a known colorant of gray-blue and gray-green papers from the 1770s, can be decolorized by alkali solutions.

b. Optical brighteners may be unstable to some wash solutions and bleaches; organic solvents used in tape removal, etc., may remove or dissolve optical brighteners.(KN) Optical brighteners can also change solubility over time.(KDB)

To verify the presence of an optical brightener examine under an ultraviolet lamp. To identify the fluorescing species use comparison sheets of known brightness, analyses, and spot tests.

c. Water and solvents may also remove color additives such as a contemporary paper dye. Tidelines are easily formed in colored papers with local solvent treatments.

d. Surface color can be adversely affected by overly vigorous surface cleaning due to abrasion or changes in optical qualities which alter visual perception.

G. Calendered Papers

1. General Description

A paper (or cloth) that has been given a smooth surface by passing it one or more times through a calender. These are "horizontal cast iron rolls with hardened, chilled surfaces resting one on another in a vertical bank at the dry end of the papermaking machine" (Roberts and Etherington 1982, 44). Types of finish include: a) antique: a paper that receives a minimum of calendering; b) machine and English: a paper that receives increasingly more calendering; and c) super-calendered: a highly glazed paper (Roberts and Etherington 1982, 44).

2. Inherent Problems

Loss of calendered surface. Surface abrasion or burnishing will leave visible marks on a calendered surface.

3. Treatment Observations

a. Aqueous treatment may cause alteration of the compacted, often shiny paper surface through swelling of the paper fibers with moisture contact. Characteristics of the calendered surface may be difficult or impossible to reintroduce.(NA) The high pressure and hard surfaces used in the original papermaking process are needed to recreate the characteristic surfaces.

If media permit, surface character can be reestablished with a variety of techniques: drying face down on glass with pressure from above, spraying with very dilute gelatin solution and drying face-down on silicon release or polyester film, or burnishing (directly on object or with an interface to increase/decrease gloss).(CS) Where media allows, flattening in a press between rag board may be more successful in restoring surface than pressing with blotters under weight.(LP) It may be possible to use a barrier sheet such as silicone release or glassine.

b. To reduce surface dirt, use grated white vinyl eraser, lightly rubbed. It may not be possible to remove all surface grime.(AS)

containing filler will contain less fiber than the unfilled sheet, and will be weaker.

c. Alkaline loading materials, such as calcium carbonates, may act as a buffer. This explains the relative good condition of loaded papers made from poor quality fibers.(LP)

d. Deep creases, folds, and dents to these papers often result in a distinctly different color along the line of damage.(CS)

3. **Treatment Observations**

a. Water stains loaded papers very easily (e.g., gray Oriental clay-loaded papers favored by Matisse for lithographs).(KN)

b. Lack of internal and surface strength may cause problems with hinges shearing off and mends and infills may be difficult to remove. Moisture must be kept to a minimum in the above treatments to avoid tidelines and staining.(TF)

c. Loading of calcium sulfate may be lost in repeated cycles (five) of float washing/drying (Cohn 1982; Daniels 1986, 71-72). Loadings in papers used in modern posters can be lost in water washing.(KDB)

d. See also **4.4.3 A. Japanese Papers.**

I. **Artists' Coated (Prepared) Papers**

1. **General Description**

a. Metalpoint papers: White papers were traditionally coated with a liquid ground, usually white lead or powdered bone or shell, sometimes mixed with colored pigment. The binder was usually gum arabic or animal glue. The dried ground was burnished. More recent grounds have included barium sulfate, zinc oxide, titanium oxide and other modern white pigments.

b. Dry-tinted papers: Dry pigment or pastel is rubbed into surface.

c. Wet-tinted papers: Paper is dampened and sometimes stretched; it is then tinted with a thin glaze of watercolor, drawing ink or other aqueous colorant. M. W. Turner, for example, is known to have prepared his own papers. "One such paper is known...to have been stained with 'tobacco juice and Indian ink'" (Richmond 1990, 4).

2. **Inherent Problems**

a. Artists' coated papers may exhibit abrasion or burnishing of surface, flaking of ground (caused by drying out of binder and aggravated by an excessively dry environment), inability of coating to withstand the dimensional response of paper to fluctuating relative humidity, creasing and folding of paper.

b. Stains form easily in the absorbent ground layer which limits use of aqueous treatments to reduce stains or discoloration.(NA)

c. If the coating is heavy and applied to only one side of the sheet, humidity fluctuations over time may result in draws, undulations and bulges that are impossible to remove. Heavy inks on top of the coating magnify the problems (e.g., silkscreens by Andy Warhol and Josef Albers).(CS)

3. **Treatment Observations**
See **4.4.2 J. Coated Papers.**

J. **Coated Papers**

1. **General Description**
Coated papers are paper (or board) which has had its surface modified by the application of clay or other pigment and adhesive materials, etc., to improve the finish for its intended use (Roberts and Etherington 1982, 57). After the second half of the nineteenth century, a sustained technical effort led to the development of mechanical methods for coating paper on a commercial scale, either on the actual papermaking machine or on a separate machine. Coating of papers has been used widely during the twentieth century to give a smooth surface for printing, especially for the photomechanical printing of illustrations (e.g., the reproduction of fine half-tone blocks). One or both sides of the paper substrate may be coated to give a more uniform/more receptive surface on which to draw or print than is obtained with uncoated fibers. Coatings control ink absorption and ensure even transfer of printing ink. They

enhance graphic reproduction, especially with multiple colors, and increase opacity and gloss of paper. A coated sheet may be calendered to impart a higher gloss. Coatings can also give the paper a different color.

a. Pigment coating: A pigment-coated paper consists of a base paper covered by a layer of pigment particles (most common include clays - usually kaolin, a refined clay - titanium dioxide, calcium carbonate), and zinc oxide (for direct electrostatic copies [KN]); an adhesive binder (animal glues, pre-1895; casein, late nineteenth century; starch, early twentieth century; soy protein; synthetics, late 1940s) which holds the pigment particles together and to the surface of the paper; and some auxiliary agents (defoamers, lubricants, wax emulsions, preservatives, flow modifiers, insolubilizers, etc.) (see Casey 1983, 2013-2189).

b. Functional coating: These coatings are designed for purposes other than printing enhancement, to produce surfaces with functional properties (barrier, etc.).

2. **Inherent Problems**

a. Some have little strength. Can be very stiff and/or brittle.

b. Zinc oxide and titanium dioxide are known photosensitizers of cellulose.

c. Coated papers are generally very sensitive to and easily damaged by moisture or humid conditions.

d. The surface of a coated paper is easily damaged or stripped. Scratches and abrasions scar and dull or burnish the finish.

e. Heavily coated papers or embrittled coatings can crack or flake and the coating can pull away.

f. The surface can absorb extraneous material like resins or oils from adhesives. This causes embedded stains which are difficult to remove (Baker, van der Reyden, Ravenal 1989, 1).

g. Inks or paints applied to a coated surface may not bond well, resulting in cleavage. For example, Andy Warhol's silkscreens.(CS)

3. Treatment Observations

a. Options for the conservation treatment of coated papers are limited. The use of dry cleaning agents or solvents to remove dirt and stains can lead to cracking and flaking of the ground or to changes in surface appearance (color, refractive index or reflection change) (Baker, van der Reyden, Ravenal 1989, 1).

b. Coated papers that have become wet will fuse together as they dry. If adequate steps are not taken to separate and treat the material when it is still wet, permanent damage can result. Freeze-drying has proven especially useful for some, but not all, types of coated papers (Parker, 1989, 4-6,8).

c. Solvent treatment can cause ring stains.

d. Washing can darken clay coatings. Also, characteristic surface gloss is altered by wetting; this is difficult to recreate through conservation treatments.(NA)

K. Western Tissue Papers

1. General Description

Western tissue papers are very lightweight paper made from any type of pulp and may be glazed or unglazed. Some tissues are relatively transparent (Roberts and Etherington 1982, 265).

a. Glassine tissue: A translucent paper formerly produced by heavy beating in the pulp stage, followed by acid surface treatment. Currently neutral glassine is made translucent with glycol. Glassine is often used with works on paper as a "heavier-weight" interleaving or "slip-sheet" tissue when translucency and great smoothness is important. (See also AIC/BPG/PCC 40. **Matting and Framing** 1988, 10).)

b. Soft tissue: The soft tissue industry developed in the United States during World War I. Soft tissue is absorbent and strong. It is often made of a combination of high-grade waste and wood pulp.

2. Inherent Problems

a. Glassine tissue: Acid-process glassine is, of course, inherently acidic.

3. **Treatment Observations**

   a. Very sensitive to water, expands greatly when wet and distorts readily.

   b. Neutral glassine may be suitable for temporary interleaving purposes though sharp edges may be problematic near fragile media on paper supports and it may become more acidic in time. It is very reactive to moisture, distorting severely and is dimensionally unstable with environmental cycling. Nevertheless, many collections prefer to use glassine because it is "see through."(NA)

L. **Tracing Papers**

1. **General Description**
A thin paper with a hard, smooth surface characterized by excellent optical transmission properties. "Important properties include proper receptivity to drawing ink and transparency, so that prints from the tracings can be made" (Roberts and Etherington 1982, 267). Tracing papers before the late eighteenth century rarely survive due to their fragility.

   a. Prepared tracing paper: Linen–flax, hemp, or linen rag–(nineteenth century) and cotton (twentieth century) pulp papers are impregnated in a separate operation with gums, oil and/or resin to transparentize (Mills 1986, D62-3). Mills identified drying and non-drying oils, pine resin, etc. in GLC-MS analysis of some nineteenth century English tracings.

   b. Parchment paper (vegetable parchment), Pergamyn, Papyrine, etc: The already formed but unsized paper sheet is subjected to a brief sulfuric acid bath. This "attacks and dissolves the cellulose and changes its fibrous form...(so that it) is altered in character to resemble parchment" (Yates 1984, 21). Then the sheet is washed in water, given a dilute ammonia bath to neutralize the acid and, sometimes, a coating or bath of glycerine or glucose. "On drying the paper shrinks considerably but it is greaseproof and much stronger" (Yates 1984, 21). Early parchment papers were made from rag papers; modern "vegetable parchments" are made from sulfite pulp paper.

   c. Imitation parchment (vellum): Chemical wood pulp paper given a prolonged beating or sulfuric acid treatment to render it grease resistant and waterproof and partially transparent. This is "a type of relatively strong paper first produced by W.E. Gaine in 1857...(it) is called imitation parchment in order to distinguish it from parchment paper made in imitation of true (animal) parchment" (Roberts and Etherington 1982, 136).

d. Natural tracing paper: "Natural tracing papers are manufactured from selected wood pulps to give an optimum balance of translucency and strength. The mechanical treatment of the fiber, or refining, is designed to maintain fiber length and change the structure of the fiber to increase its surface area. During the formation of the sheet of paper, it is this feature which contributes most to the construction of a dense sheet of cellulose. Further compression and compaction of the sheet produces a paper virtually void of interstices, thus free of internal light-scattering interfaces. Unlike prepared papers, natural tracing papers are substantially free of papermaking chemicals. The paper is made at pH conditions close to neutral and the temperature at which the paper formed is high enough to kill most of the microbiological organisms that could cause paper decay. It therefore follows that modern natural tracing papers do have good aging characteristics. Even the size which is applied to give a surface receptive to drafting inks is selected to minimize acid hydrolysis" (Rundle 1986, D64-65). Natural tracing paper of circa 1825 has been observed at the National Archives and Records Administration.(KN) As developed in U.K. in 1939, the process included the addition of starch, but by 1950 starch was no longer required to produce translucency. Scanning electron micrographs of modern natural tracing paper show general fiber damage and fibrillation, but no impregnating agent (Priest 1987, 76).

e. Onion skin: "...Thin, highly glazed translucent paper" (Yates 1984, 21).

f. Waxed paper: "Paper passed through a bath of melted wax" (Yates 1984, 21).

2. Inherent Problems

a. Tracing papers in general react very dramatically to moisture changes; they expand, cockle and wrinkle easily. Oil/resin prepared tracing papers are less reactive, however, than natural tracing papers which have a greater capacity to expand with moisture. Cockling of the support around pigment wash areas may be an inherent characteristic of some works on tracing papers.

b. With aging, prepared tracing papers may become extremely brittle and discolored because of the presence of impregnates, especially when stored in a poorly regulated, acidic environment.(SRA)

c. Translucency makes the addition of unobtrusive hinges, mends, fills and linings problematic.

d. Adhesion of starch pastes are problematic with some impregnated papers.(LP)

e. Storage: Large works on tracing paper may require rolled or folded storage; this may cause problems of access, especially when the support is deteriorated. The ends of the rolls are often damaged.

3. **Treatment Observations**

a. In the case of tracing papers that have impregnating agents, treatments can interfere with the original appearance and remove material evidence. Some solvents may cause loss of translucency on some papers as a breakdown of impregnating agents (Baker, van der Reyden, Ravenal 1989, 10). It is suggested that treatments to these types of papers should be kept to a minimum. Conversely, natural tracing papers that have been transparentized by extensive beating of the fibers can withstand extensive treatment (e.g., washing, bleaching, etc.) and will dry without alteration to the surface.(SB)

b. Modern natural tracing paper is much stronger than one might expect. It can be manipulated when wet, if it is well supported. Soaking in water does not always completely relax creases, but it may to the extent that the work can be flattened. The object may also be relaxed until limp using vapor from an ultrasonic humidifier.(NA)

c. Mending with Japanese paper and wheat starch paste and/or methyl cellulose is usually very successful but, because of the tendency to distort with moisture, only small areas should be worked on at a time. Heat-set tissue (e.g., Rhoplex on paper base) and BEVA mends have also been used. A slight change in appearance may be considered acceptable since it is often unavoidable. The Library of Congress (LC) heat-set tissue works on some tracing papers and when applied with ethanol rather than heat or in combination with heat is almost invisible. More invisible mends can be obtained with a "gossamer tissue" coated with Klucel G developed by F. Mowery. (On the other hand, the Mowery tissue does not offer as much support as the LC tissue.[CS]) Tissue with BEVA 371 or Klucel G applied using solvent instead of heat works well.(CS) The challenge of making mends, fills, etc. unobtrusive may be met by using the optical properties provided by placing a sheet of opaque paper or mat board behind the tracing paper.(SP)

d. Backing methods include the use of traditional "wet lining," heat-activated systems, and solvent activated systems. (See Bachmann 1983 for a summary of the literature to that date.) For the wet lining of nineteenth century tracings, thin Japanese machine made roll papers and very dilute wheat starch paste are recommended; both tracing and roll papers have the same dimensional properties (Nicholson and Page 1988).

e. Be aware that solvent treatments on impregnated papers (especially with ethanol and acetone) may alter original tracing paper.(SP)

f. Drying and flattening are very important treatment steps for most tracing paper supports which are thin and dimensionally unstable. Successful methods may include the following.

Flattening with considerable weight between hard surfaces (e.g., rag board) has been successful.(NA)

Stretch drying on a screen (mizubari or karibari): moisture and friction bind the primary support between a protective wet-strength tissue on the face and false backing of a suitable Japanese paper; a line of paste is then applied around the extended edges of the Japanese paper. The object is adhered, face inward, by the pasted edges to a Japanese drying screen (also called karibari) or other board. Once dry, the object is dismounted and the false backing and protective tissue are peeled away (Keyes 1984, 101-102; Futernick 1984, 68). Not suitable for objects that are weak, brittle, or damaged by tears or weak fold lines.

Friction mounting: Combines the use of a false backing (described above) with pressing in a press or between plate glass sheets and under weights. Far less moisture and friction contact are required in this method so that moisture can be reduced to a minimum for vulnerable objects. "Vapor humidification in a chamber or contact humidification between moist blotting paper provides enough moisture for successful friction mounting" (Keyes 1984, 102-104; Fletcher and Walsh 1979, 122-124). Friction mounting may also be undertaken without using a press; sometimes thick felts will provide adequate pressure.(SRA) Felts are useful because they conform to the surface irregularities of sharp creases often present in tissue paper which has previously been folded.(SP)

In all cases it is important to match the grain directions of the original support and the secondary mounting papers.

Friction mounting variation: Place a totally relaxed object face-down onto glass; smooth, thin porous Hollytex on top of object; a blotter extending beyond the glass above the Hollytex; glass and weights. The protruding blotter allows moisture to be removed from sandwich without need to open package risking the formation of cockles.(CS)

Drying against Mylar or Parafilm to encourage a smooth surface. Watch for mirroring.

Some transparent papers can be successfully flattened on the vacuum suction table after first thoroughly humidifying them. Care must be taken to avoid "blotter impression" on these thin papers.(CIM)

g. Hinging: See AIC/BPG/ PCC **40. Matting and Framing** 1988. One successful method for hinging lightweight papers is to make tiny cuts in the "attachment edge" of the hinge and remove alternate segments, creating a "tiny comb." Paste only 1 mm of the comb and attach it to the object. Attach hinge to back board 5 mm above the top edge of the object. This method solves the problems posed by the transparency and dimensional instability of tissue and tracing papers (Futernick 1984, 68-69). An alternate hinging method uses hinges made of Hollytex Lite prepared with dilute Lascaux 498-20x or 498-HV which can be reactivated with appropriate solvents or with heat.(AM) Non-impregnated tissue paper may be hinged by application of heat-set tissue and detached with solvent.(SP) For tracing and other papers that are very slick, very calendered, etc., small squares of double-sided tape may be used instead of traditional hinges. This has mainly been for exhibition purposes: the tape has been easily removed after a few years, however long-term stability, etc. is unclear.(KDB)

h. Polyester film (Mylar) encapsulation is also a satisfactory way to support tracing paper inside mats. Encapsulation provides physical support, however, be aware that Mylar has strong electrostatic properties and that tracing paper may be torn easily while working. Encapsulation is not recommended for tracing paper with graphite media.(SP)

i. Preserve through environmental control. House in special mats to prevent mishandling. Matting these papers can create great danger; the paper can be sucked upwards with the opening of the mat. See AIC/BPG/PCC **40. Matting and Framing** 1988

j. Transparentizing material is original and its removal is ethically, as well as practically, questionable. Solvent extraction of transparentizing material such as oils is a debatable treatment, which can remove darkened oils but leave paper opaque.(KN) The paper after oil extraction may be discolored and embrittled.(TF) Removal of transparentizing materials is sometimes necessary if the image is to become visible again. Have high-quality photographs made before extraction. Explore the possibility of adding an archival quality impregnate after removal of the discolored one.(CS)

M. Cardboard/Artists' Board/Illustration Board

See AIC/BPG/PCC **24. Backing Removal**, 1985.

1. General Description

A board 0.006" or more in thickness. It is stiffer than paper (Roberts and Etherington 1982, 47). The term "cardboard" was not generally used until the nineteenth century (Krill 1987, 55).

a. **Pasteboard:** In use for bookbinding boards in the late fifteenth century; found on aldine bindings and may have been introduced into Europe from the Islamic world via Venice, Italy. The papermaker can make pasteboards by couching a number of sheets together and pressing, or by laminating several sheets of paper, either of the same size or smaller sheets pieced together. White paper could be used throughout or only on the outer surfaces of the board. Uses include book boards, playing cards, primary supports for drawing and oil paintings, and secondary supports for vellum in miniature painting.

Bristol Board: Introduced in England by 1800 it was a glazed pasteboard made of a fine wove drawing paper. "Each board was embossed with a circle containing the Royal Crown and the words 'Bristol Paper'" (Krill 1987, 139-141, figs. 121, 122). Used for making cardboard boxes, screens, and as a support for watercolors. Today the term refers to laminates thinner than "cardboard."(CS)

London Board: A more expensive board made by the 1830s from Whatman's finest drawing paper (Krill 1987 140, fig. 123).

Ivory Paper: A support for drawing introduced in the mid-eighteenth century and not very popular. It is a pasteboard composed of six sheets of drawing paper with parchment size adhesive between the layers. When dry, the board was smoothed with abrasive papers, coated with plaster of Paris in gelatin, and smoothed again (Krill 1987, 141).

b. **Pulp Paper Boards**

Millboard: Term first used in the very late seventeenth century. These boards were made of the same fibers as pasteboard, but were manufactured by casting on a mold in a single sheet and then milled or rolled under pressure (Krill 1987, 55).

Strawboard: A very coarse board that contains particulate filler - often lumps of gritty material, like gravel.(AM)

Rope Manila Board: A very durable pulp board.

Illustration Board: This commercially available product typically consists of a good quality facing paper upon which the drawing, watercolor, etc. is made; the facing paper is mounted to a cast core board of lesser quality stock. The back of the board may also be faced with a layer of paper bearing a printed inscription identifying the manufacturer, brand name, and a company address that may help in dating the object. "The usual properties of drawing paper, such as finish and sizing, are essential, but hard sizing and good erasing quality are of greatest importance" (Roberts and Etherington 1982, 136).

c. **Coated Boards** (See **4.4.2 J. Coated Papers.**)

2. **Inherent Problems**

a. Delamination of pasteboards, especially at the corners and around the edges, is a common problem. There is also a tendency to separate when damp. Breakage due to the combination of acidity and inflexibility may also occur.

b. Early pulp boards tend to be soft and spongy.

c. Thick boards may distort with moisture and are difficult to flatten.

d. Artists' Illustration Board: Acid migration from a poor quality lignified core board will discolor and embrittle the better quality facing paper which bears the image.

3. **Treatment Observations**

a. Readhere delaminating pasteboard sheets where desirable.

b. Filling losses: Cardboard often has losses with jagged cross-sections. Japanese tissue or blotters can be shaped to fit one layer of the irregular edge of the cardboard and adhered with wheat starch paste. Another layer of paper may be torn to fit into the next shape presented by the object. Repeat until the front of the cardboard is reached. Finally, apply a larger piece of strong tissue over the top of the fill and extend onto the object enough to cover the break line. Tone the laminates or uppermost layers as necessary.(CS)

In some cases, the use of paper pulp may be the best way to fill a jagged loss. "Back" fill with Japanese paper for added strength, especially with corner losses.(CIM)

c. Hinging: See AIC/BPG/PCC **40. Matting and Framing** 1988. Hinges attached to the top edge of the artwork may be pushed through slits cut in the back board so that secure attachment can be made on the back of the mat board (Futernick 1984, 69-70). Use a sink mat to create a ledge below the object for it to sit on. Add a "fence" to the other three sides so they protect against swinging of the heavy object and against physical damage to the laminate edges.

d. One must consider the importance of the board to the historic/artistic integrity of the object versus the need to remove the board for the long-term preservation of the image and/or primary support. Separation of the primary support from the secondary core if necessary/possible is tedious, difficult, and time consuming. The loss of structural integrity to illustration board may be offset by the risk to a thin primary support by an embrittled secondary support. See AIC/BPG/PCC **24. Backing Removal** 1985.

N. Drawing Papers

1. General Description

"The term 'drawing' paper was rarely seen in artists' manuals before the end of the eighteenth century...it was not until the 1790s that artists regularly began to use it" (Krill 1987, 83). Gainsborough and other artists used writing paper, which was well-sized, despite its laid lines and glazing, for watercolor or ink (Krill 1987, 83). "For works requiring careful detail, a glazed paper was more suitable...Baskerville had been glazing [between two steel rollers] both printed...and unprinted paper, especially writing paper since the 1750s" (Krill 1987, 89). John Hassell, writing in 1809, recommended two drawing papers - Whatman's wove and Dutch Cartridge. The latter "had a 'rough tooth' and was 'much in vogue'...was a large thick paper and of better quality than the coarser papers used by Girtin [cartridge]. Though it was usually white...it also could be made of mixed furnish." Dutch Cartridge was still used around 1870 (Krill 1987, 85-86). Whatman's wove paper is also mentioned in **4.4.2 O. Watercolor Papers**; Cartridge paper is mentioned in **4.4.2 O. Watercolor Papers** and described more fully in **4.4.2. Artist's Printing Papers.**)

Oriental papers: Soft-sized or waterleaf papers were also used for drawing when an artist wanted a more diffuse, less detailed, less contrasting image that allowed the media to blend with the paper.(AD)

2. Inherent Problems

3. Treatment Observations

O. Watercolor Papers

1. General Description

A thickish and uniquely hard-sized wove paper; the ascent of the British watercolor school is attributed in part to the development of wove paper by James Whatman in the late eighteenth century. It was considered "the best and proper paper for all serious efforts" (Cohn 1977, 18). English papers used for watercolor before Whatman's development were more weakly sized which made manipulation of the medium difficult because the paper surface would abrade easily. Sizing instructions appeared in artists' manuals. The Art of Drawing and Painting in Watercolors (1778) gave a recipe for sizing paper which was a combination of alum and roch-alum (Krill 1987, 84). Whatman paper was sized to minimize dimensional change when wet and to provide a durable surface that could be manipulated by scraping, rubbing, sponging, wiping, rewashing, etc., without becoming abraded. Paper made from linen rags was thought to withstand these techniques better than paper made from cotton (Cohn 1977, 22).

An even surface was desired for painting. An acceptable range of surface textures, available by 1850, included hot-pressed – a smooth, relatively non-absorbent surface, the intermediate "NOT" (i.e., not hot-pressed), and cold-pressed – a softer, rougher and more absorbent surface. The tooth is particularly important for watercolor; its slight irregularity "...enhanced the reflection of light and added to the vibrancy and luminosity of the washes" (Krill 1987, 89). Manual writers stressed the importance of texture to produce effects peculiar to watercolor (Cohn 1977, 16).

Other desirable properties include consistent absorption properties – the paper should be only slightly absorptive in the short run or the colors will "sink" and become dull, washes do not run smoothly on unabsorptive papers but tend to coalesce into droplets; ideally the paper was white so that light would be reflected through the layers of color and provide the highlights of the design where there was no media. "These requirements were not fully met by paper available before the end of the eighteenth century" (Cohn 1977, 16).

Other papers offered artists qualities of color, texture and sizing that suited their needs: "Cox's" paper, "sugar paper," Cartridge, Creswick, Harding, Griffin Antiquarian, etc. are some examples (Cohn 1977, 19).

To eliminate the need for stretching by the artist in preparation for use, some commercial watercolor sheets are made of a high quality paper mounted on cardboard and often backed with another paper sheet (see **4.4.2 M. Cardboard/Artists' Board/Illustration Board**) (Cohn 1977, 23).

Addition of glass fibers and/or a blend of rag and synthetic fibers increase the dimensional stability of some modern papers.

Other supports for watercolor include Oriental papers, "unsized in the Western sense," which were used in the West to obtain distinctive effects (Cohn 1977, 17); Japanese vellum papers (see **4.4.3 A. Japanese Papers**); silk and linen; and colored papers. Machine made papers may be manufactured in imitation of handmade watercolor papers (Cohn 1977, 22; see also **4.2.1 I. Surface Texture**).

2. Inherent Problems

a. Commercial watercolor board: Survival of the facing paper depends on the quality of the core. Acidity from the cardboard core can migrate to the facing paper, causing embrittlement and discoloration. See **4.4.2 M. Cardboard/Artists' Board/Illustration Board.**

b. Casual selection of watercolor papers by some twentieth century artists practically guarantees the use of machine made paper, sized with alum-rosin. See **4.4.2 E. Alum-Rosin Sized Papers.**

c. The potential for cockling is a characteristic of all papers; it is usually a function of the thickness of a sheet (see **4.2.1 D. Thickness**) with thinner papers being more susceptible.

3. Treatment Observations

a. Distortion of technical evidence with change in dimensions during aqueous treatments: the size of a watercolor, taken before treatment, may be a fraction of an inch larger than the standard dimensions of nineteenth and twentieth century commercially available watercolor papers. "By wetting and stretching individual sheets prior to painting, the artist would inadvertently increase their dimensions by as much as one-half inch, a size they retained when freed from stretching" (Walsh 1987, 54). Further change may result depending on drying/flattening methods selected.

b. Alteration of original technical evidence can result from flattening of cockling that occurred during execution of the watercolor.(NA)

c. Technical evidence may also be lost when remnants of "watercolor block" binding material along the outer edges of a sheet are inadvertently removed in treatment, or if a secondary board mount, to which the primary support was attached before execution of the watercolor, is removed since brush strokes often extend over the paper edge onto the board.(NA)

d. Washing and drying treatments can increase/decrease the surface texture of some watercolor papers if not accomplished carefully by an experienced conservator.

P. Artists' Printing Papers

1. General Description

a. **Rag paper:** Artists used papers made of rag fibers from early times as supports for prints. These could be strong enough "to withstand dampening and printing under great pressure. (The) surface (was) receptive to ink, neither too rough nor too hard...(They) tended to change color very little with age, mellowing only from white to warm creamy tones" (Boston Museum of Fine Arts 1969, 178). The finest qualities of rag paper could give brilliant impressions with fine detail that was very legible. By the later nineteenth century Lalanne (1880, 72) noted the preference of "most people" for heavy Dutch handmade papers for etchings; charcoal paper and other good drawing papers also sufficed. The laid texture of paper broke up the line, giving highlights within it (Lalanne 1880, 59). Old papers with "brown and dingy edges" were sometimes prized by later nineteenth century printmakers (Lalanne 1880, 59). Because the "sizing has decayed in old papers and the fiber, in consequence, regained its pliability...these take an impression so much more sympathetically" (Lumsden 1924, 139). Lumsden also remarks on the "subtle color" of old paper (Lumsden 1924, 139). For him, soft-sized paper makes the best etching paper; waterleaf paper is "entirely undersized." Most drawing and etching papers are heavily sized (Lumsden 1924, 139). For mezzotint paper English printers in the nineteenth century preferred the French laid paper that was of hammer beaten linen fiber.(AD)

b. **Plate paper/copper-plate paper:** Used for printing from copper plates, it was relatively soft, even surfaced (a result of the use of the wove mold, available late 18th century), free of flaws and absorbent, with little or no sizing (eighteenth century: generally soft-sized; nineteenth century: often unsized). Softness was obtained by reducing sizing and by adding more pliable cotton fibers to the linen furnish. This became common in the early nineteenth century as cotton became more abundant. A thickish paper is required for printing from copper plates; it is too easy to damage the sheet in printing if it is both thin and soft (Krill 1987, 68, 77). During the early nineteenth century "the English vatmen would form each sheet with two layers of pulp - one of ordinary consistency and then, on the side of the sheet destined to take the impression, a second extremely thin layer of especially fine pulp, completely free of foreign matter" (Dyson 1984, 166). Nineteenth century etchers used plate paper to assess the appearance of a plate as it developed; the artist would then usually select a finer paper to print an edition. Artists' manuals described "plain white plate paper" as the worst support for etchings "because (it is the) most inartistic" (Lalanne 1880, 72). Degas, however, frequently printed his etchings on plate paper possibly because of "its effectiveness in rendering the tonal qualities he sought" (Perkinson 1984, 255). Plate paper was often used as a support for nineteenth century chine collé prints published in large editions.(KN)

c. **Oatmeal or Cartridge paper:** A cheap, rough, grayish-brown European paper with small flecks in it, made from the leavings of the vat. Oatmeal paper contained a high proportion of unmacerated and varicolored fibers, bits of string, fiber clumps and chips of wood or straw (Robison 1977, 9). Oatmeal seems to be a general descriptive name used by curators to describe a thick coarse paper flecked with dark fibers.(KN) This paper was not made as an art, writing or printing paper, though artists appreciated its texture and appearance. It was used by Rembrandt, for example, on several occasions (Boston Museum of Fine Arts 1969, 180). Oatmeal paper offers a middle range of values; impressions "have a softer, more delicate tonal effect...with a far less stark contrast than...impressions on white (rag) paper" (White 1969, 14). It appears to be a type of utilitarian paper, commonly called cartridge paper, and used to make paper wrappings for rifle cartridges, hence the name.(KN) Today "cartridge paper" refers to a tough, closely formed paper, usually produced from chemical wood pulps and/or esparto. Sizing and surface characteristics depend on intended use (Roberts and Etherington 1982, 47).

d. **Vellum:** Etchings and engravings printed on vellum were a rare occurrence in seventeenth century Holland except for Rembrandt's work (Boston Museum of Fine Arts 1969, 180); however, earlier Dutch prints on vellum do exist. In seventeenth century France, portraits were occasionally printed on vellum. With the revival of interest in unusual support materials in the mid-nineteenth century, vellum was again used (e.g., Félix Buhot). Vellum is an unabsorbent material; ink is held on the "almost glassy" surface and does not penetrate at all. Ink tends to "bleed outward over the surface, thus fusing neighboring lines" (Robison 1977, 15).

Imitation vellum was manufactured in the late 19th century since interest in vellum exceeded supply. It was used for "appropriate tonal impressions (and) reproduced the color and transparency and even the slick, slightly 'glassy' surface texture of the real skins" (Robison 1977, 15). For a general description of vellum as a support material see **4.4.6 C. Parchment/Vellum.**

e. **India paper** (so-called; also known as India, India proof, India transfer paper): According to Labarre (1937, 160) this is really China paper. The name is an English term that may be a misnomer derived from its having been imported by the Dutch East India Company.(KN) The name is sometimes loosely given to other papers of Asian origin, but also to papers of European and American manufacture (Labarre 1937, 160).

An off-white paper, varying in tone, without prominent laid lines but with yellow fibers throughout. This soft, unsized paper "adapts itself to the surface of the steel plate or wood, and soaks up a large quantity of ink without afterwards smearing" (R. Perkinson, A Treatise on Paper, London 1894 as quoted by Labarre 1937, 160). Thought to have been used by Rembrandt for several impressions, this paper is very absorbent and gives rich soft effects, particularly suited to the qualities of drypoint

(Boston Museum of Fine Arts 1969, 180). Mentioned by Lalanne (1880, 59) as promoting "purity of line." India paper has been a thin, opaque paper made from chemically processed hemp and rags since 1875 (Roberts and Etherington 1982, 138). The British successfully imitated this paper with "Oxford India," a very white paper which somewhat resembled Western cigarette paper (also called "Cambridge" and "Bible") (Dwan 1989).

f. **Japanese papers**: First imported into Europe in quantity in the seventeenth century. When printed, this smooth paper "receives the ink very well from the plate, but instead of absorbing the ink into the substance of the paper like European sheets, Rembrandt's Japanese paper holds the ink on the surface, keeping it all there and fully visible" (Robison 1977, 13 referring to Rembrandt's use of Japanese paper). The polished, soft surface "receives ink readily under minimum pressure and so does not wear down fine drypoint lines and burr as quickly as rougher paper surfaces tend to do" (Boston Museum of Fine Arts 1969, 180). It was also capable of taking very rich impressions. Lalanne notes the excellent qualities of Japanese paper which is "...of a warm yellowish tint, silky and transparent, is excellent, especially for plates which need more of mystery than of brilliancy, for heavy and deep tones, for concentration of effect..."(Lalanne 1880, 60). Lumsden (1924, 139) also noted its beauty of color. In the nineteenth century, Whistler made abundant use of a variety of Japanese papers. Gampi was preferred by 19th century European wood engravers because it allowed them to achieve the finest detail (e.g., A. Lepère). For a general description of Japanese papers as support materials see **4.4.3 A. Japanese Papers.**

2. **Inherent Problems**

a. Plate paper/copper plate paper is vulnerable to mold and foxing stains. Grime is easily embedded into the paper surface.

b. Vellum has a very nonabsorbent, glossy printing surface. The printing ink may not penetrate the surface resulting in flaking of the media, particularly with fluctuations in ambient relative humidity/moisture content. Ink may be easily abraded, especially at the high points of a cockled sheet.

c. Japanese Papers: Gauguin is known to have printed some woodblocks in black ink on a support paper, and then covered the support (and printed image) with a thin tengujo (kozo) veil. He recut and printed the block on top of the tengujo. It is almost impossible to see but important to know about before treatment (Dwan 1989, 9).

Nineteenth century prints on Japanese papers often show a shiny, burnished area from contact with the metal plate during printing; this contrasts beautifully with the matte, unprinted and unpressed margins. The burnished area can easily be damaged by abrasion, distortion, or swelling during aqueous treatments (Dwan 1989).

3. **Treatment Variations**

a. Plate paper/copper plate paper: Dry cleaning may be difficult. Plate impression may be lost during treatment.(AD) Crisp, fresh plate impressions in particular may be affected. However, sometimes a squashed or barely visible platemark may be revived somewhat through aqueous treatment.(NA)

b. Blind stamps, printers' chops, and other embossed marks can be reduced in crispness during aqueous treatment. The finer and more detailed the stamp, the greater the tendency toward softening of detail.(NA)

4.4.3 Asian Papers

A. Japanese Papers

1. **General Description**

Traditional handmade papers from Japanese bast fibers (kozo, mitsumata, and gampi) are long-fibered or short-fibered, relatively unidirectional, strong, thin or thick, flexible or stiff, absorbent, white, cream or brown, translucent or opaque, soft or crisp. If the fiber has not been over processed, there is always a characteristic luster to the fiber. The variety of handmade papers from Japan is related to the number of papermakers and the end use. There were thousands of hand papermakers before the machine made papers put them out of business. There are several hundred papermakers today, however, only a handful of paper mills operate using the traditional handmade paper methods.(YN)

Traditional Japanese papers are made from bast fibers which make up the inner white bark of specific, young trees. The bark is stripped from the inner core of the tree after steaming. Most of the outer black bark is removed by scraping. The inner white bark is cooked in an alkali solution to remove most of the non-cellulosic materials, loosen the remaining black bark, and begin to separate the fiber bundles. Traditionally, the cooking alkali was potassium hydroxide which came from wood ashes. This is a very gentle process of fiber preparation. Since approximately 1890 soda ash (sodium carbonate), a stronger alkali and caustic soda (sodium hydroxide), a strong, harsh alkali, have been used to cook the fibers. Slaked lime (calcium hydroxide) has also been used as the alkali, but is now used in only a few places. Caustic soda produces quick results and is often the chemical of choice to be used in combination with bleaches to produce white paper. This paper has a soft, pulpy feel and less luster. Papers made from fiber cooked in caustic soda will initially be quite bright and white, but weak. Color reversion due to the over processing with harsh chemicals is likely. After cooking, the fibers are rinsed well, otherwise residual chemicals can cause discoloration or spotting. The fibers are beaten almost to the point of fiber separation rather than cutting them in order to obtain a long fibered paper. One distinguishing factor between Western and Japanese papermaking is the use by the Japanese of a viscous agent (neri) derived from the Hibiscus root (tororo-aoi). The secretion is not a size or a gum; it merely thickens the water in the pulp vat for a while to suspend the fibers while the sheet is formed. This allows the long fibers to become intertwined and permits multiple dips. This substance can allow the sheets to delaminate during treatment. The secretion is not detectable in the dried sheet. The sheets are couched directly on top of each other, pressed lightly, then individually brushed onto wooden boards to dry. This will often leave an impression of the wood grain. The brush can also leave detectable marks on the sheet. The brushed side will have more tooth and is usually the side pasted in lining treatments. Modern methods now include steam heated dryers which are made of stainless steel or cast iron. Foxing has been noted on one side of some lesser quality papers.

The first papermaking company to produce machine made papers in Japan was founded in 1873. Cotton rag papers were made for the burgeoning publishing industry. Machine made bast fiber papers were not available until sometime after. Problems with foxing and over processing of fibers resulting in color reversion and loss of strength can be associated with some of the early machine made papers. Recently, technology has made it possible to produce machine made Japanese papers which are useful for conservation due to their purity and large size.

Each of the fibers has its own characteristics.

Kozo

a. Kozo fibers are generally tough, and tend to be naturally whiter than other fibers. Kozo papers can be very thin and somewhat transparent (used for lacquer filtering) or thick and opaque (used for wood block printing). Scroll and screen mounting in Japan is done mostly with kozo fiber papers (such as usumino, misu, uda and sekishu).(YN)

b. Kozo papers sometimes contain a clay filler which increases opacity, dimensional stability, and smoothness.

c. When moistened for printing (Ukiyo-e) certain kozo papers remain relatively stable in dimension. This is important to ensure exact color registration.

d. Hosho is the traditional wood block printing paper produced from kozo fibers; it is available in various weights and is contains a talc filler which makes the paper very smooth, absorbent, dimensionally stable, and white in tone. The paper mold is dipped several times during sheet formation (Dwan 1989).

Gampi

a. Gampi fibers are shorter than kozo and browner, due to the non-cellulosic components. Gampi paper is particulary known for its luster and silkiness. Gampi papers can be thin and transparent, giving the impression of membrane. They also can also be quite thick like the coveted Torinoko paper or "Japanese vellum." Gampi is quite tough and is used as interleaving for beating gold to make gold leaf. The fibers are so fine, that a special waterproofed silk cloth called a "sha" is used to cover the papermaking screen. This covers the chain and laid lines resulting in woven look for most gampi papers. Gampi was used extensively for mimeograph both in the West and Japan. It was one of the first products exported from Japan to the West.(YN)

b. Gampi fibers are used in thick, opaque, yellowish Japanese vellum papers (torinoko). The thickness is the result of many dippings. Often this characteristic may be identified when the edges are inspected; these layers can be delaminated with a spatula. The main purpose of this paper is for painting because of the smooth and beautiful surface. It comes in different grades based on the purity of the gampi fibers.(YN) Texture is an important characteristic: these papers are calendered or filled to make them smooth. The color of the paper shifts when supplementary kozo or mitsumata fibers are added. "An imitation, made by treating ordinary paper with sulfuric acid, is sometimes called 'Japon'" (Roberts and Etherington 1982, 143).

Mitsumata

a. Mitsumata fibers make a naturally browner paper due to the higher non-cellulosic components in the fiber itself. The fibers are shorter, hence the papers are generally more opaque.

b. Kyokushi (Japanese vellum paper) was developed in 1874 by the Meiji government as a security paper. It was considered excellent for this purpose since alterations were easily detected. This quality makes conservation treatments difficult. It was made "Western-style," couched between fabric, and looked very much like a Western wove paper. It may or may not be calendered on one or both sides. Its unique color and receptivity led to its use and popularity with nineteenth century European printmakers who knew it as "Japon" (kyokushi) (Dwan 1989).

c. Gasenshi, a thin, very white paper, more commonly called China paper or India paper, is made with a combination of bamboo and mitsumata fibers (see **4.4.4. A. Collé Paper**). A rice starch powder (wara) is added as a filler.(AD) The name means "imitation calligraphy paper." It was also made in China and by the Japanese from an early date in imitation of the Chinese paper. The imitation mold gave prominent regular chain and laid lines with approximately half the spacing of other Japanese papers (1.5 to 3.0 cm).

d. Japan "simili" papers: By the twentieth century European mills produced paper in imitation of these Japanese papers (Dwan 1989).

2. **Inherent Problems**

a. As in any industry, the quality of paper manufacture varies greatly. Many Japanese papers are in beautiful condition, but may have discolored with age and/or developed foxing. This can be due to the addition of mechanical wood to the pulp, impure water, iron used in the manufacturing process, alum rosin size, drying on heated metal panels instead of wood boards, etc.

b. Kozo: Soft, layered structure makes kozo, in particular, vulnerable to thinning and grayness from embedded dirt and abrasion (Keyes 1988, 32).

c. Hosho with kozo fibers: Because it is dipped several times during manufacture it can easily delaminate between the layers during aqueous treatment (Dwan 1989). Torinoko and Maniai-shi (gampi fibers) do the same.(YN)

d. Gampi: Strong expansion and contraction characteristics are observed if exposed to fluctuations in relative humidity or aqueous treatments. They will expand and contract more than other papers. "The plate measurements of an impression printed on Japanese paper will often be two to three millimeters smaller in both dimensions as compared with those of the same subject printed on a European paper" (Boston Museum of Fine Arts 1969, 180). Because of their thinness, gampi papers wrinkle and ripple easily and repairs can often be seen. If improperly mounted they can buckle and distort dramatically, therefore, they are not recommended for backing paper.(YN)

e. Traditional presentation in the West: Some Japanese papers are "gossamer-thin" and so were often mounted for protection (Nicholson 1988). (See **4.4.4 A. Collé Paper.**) One may encounter prints attached to the mat by a thin band of paste around all the edges or laid down with the entire verso of the primary support stuck to mat board with paste or dry mount tissue. The quality of the mat board can pose a serious conservation problem; it may contain lignin, be acidic, brittle, and discolored (Nicholson 1988, 39). Mats constructed in the traditional fashion expose these papers to potential damage when the mat is opened, as they are easily sucked upwards.(CS)

f. Sizing: To meet certain needs, some papers were sized with a mixture of gelatin and alum (doza). In some cases the mixture has caused deterioration of Japanese papers (Inaba and Sugisita 1988).

h. Spotting: Uncleaned black bark left in the paper can cause deterioration in the surrounding area due to lignin, etc. Foxing can occur due to the manufacturing process.

3. **Treatment Observations**

a. Abraded paper surface: Loose paper fibers, soiled and rolled or pilled. Cut away fiber outcroppings, "tame down" shaggy fiber projections with dilute paste or resize (Keyes 1988, 33). Methyl cellulose also works well.(CS)

b. Options are limited in surface cleaning because the papers are unsized and have a soft surface. Cleaning through another piece of Japanese paper can be helpful.(SRA) Using a thick, flattened piece of kneaded eraser which is forcefully pounced straight down, straight up, again and again is also a possible method.(CS)

c. Local discoloration (e.g., foxing) can sometimes be reduced on the vacuum suction table because the paper fiber network is so open. However, the same mobility of discoloration can cause haloes.

d. Introduction of moisture:

1) Because these papers are unsized, characteristics can be lost during aqueous treatments; however, local treatments can be successful. A. Dwan has had success retaining impression and brush strokes during aqueous treatments to remove stains by using selected alcohols (propanol) to "resist" non-treatment areas. This work is still in the experimental stage.

2) Use of steam is not recommended since it can easily create tenacious translucent stains, apparently by affecting the mucilage used in papermaking (Keyes 1988, 32).

3) Gore-Tex treatments have been very successful. Also, suction table treatments and humidification with blotters.

e. Drying/Flattening: Their thin porous structure makes some Japanese papers dimensionally unstable and prone to wrinkles and other distortions. For stretch drying on a screen and several methods of friction mounting see **4.4.2 L. Tracing Papers.**

1) To protect the burnished plate area of a Western print on a Japanese paper, a washed Japanese paper (that has been given a slick surface by drying it against a metal surface) is fitted to the plate area by water-tearing it. The smooth side of this "insert" is placed next to the burnished plate area on the washed and damp Western print; then a sheet of lens tissue and felts for final drying are added (Dwan 1989, 11).

2) Success in drying gampi is obtained by placing it between Gore-Tex (with the smooth sides facing the gampi), sandwiching this between blotters and felts, and placed under a light weight. Brush through Hollytex to ensure contact of the gampi with the Gore-Tex. The smooth surface of the Gore-Tex retains the smooth surface of the gampi, yet allows water to be removed equally from both sides of the sheet. The light weight and light restraint of the Gore-Tex sandwich helps to retain the impression of modern Western prints (Dwan 1989, 10).

3) Gampi can be dried on/or against Mylar or Parafilm sheeting to avoid problems of edge adhesion. In the past, glass has also been used as a smooth surface on which to stretch-dry gampi.

f. Gasenshi is unsized and very absorbent, but weak and easy to abrade in surface cleaning, easy to skin, and easy to lose textures (prominent brush marks from traditional drying process, calendered surface, matte and burnished areas from metal plates used to print Western prints) in aqueous treatments and subsequent drying and flattening (see **4.4.3 A. Japanese Papers**) (Dwan 1989).

1) Local treatment on gasenshi papers may cause permanent tide lines because of the white-tone from

a filler (wara, a rice straw powder). This filler is very absorbent. It is probably this that moves during aqueous treatment and produces white tide lines by redeposition. Use of amylase enzymes is contraindicated because of the presence of the starch based filler (Dwan 1989).

g. Resizing is appropriate for most traditional Ukiyo-e (Japanese woodblock prints) but not for surimono (a category of privately commissioned prints used for seasonal greetings and announcements on lightly sized or unsized paper) or other unsized sheets (Keyes 1988, 30). "Resizing may be considered when the print is limp and lacking its normal body, when the paper surface has been roughened and fibers are loose, when repair was extensive and the general tension balance needs to be established or when large areas have been treated with enzymes. Good quality gelatin is used in a concentration of 0.5% or less. It is normally applied in a spray, but the manner of application may be adjusted to accommodate the tolerance of the colorants present" (Keyes 1988, 33). The papers, if traditional, were sized with the mixture of gelatin and alum called dosa. Test for protein and resize with a good grade of gelatin. The size may have been applied on one side only.(JM)

B. Chinese Papers

1. General Description

Chinese was developed initially for writing in ink. It is very absorbent and comes in sheets made of single, double, or multiple layers.(YN) The earliest paper was made from hemp and paper mulberry; eventually a wider range of materials was introduced including rice straw, bamboo, various barks, etc. Hundreds of types of paper are mentioned in early Chinese literature. The best, then and now, is made from bast fibers. Traditionally, because of slightly different fiber preparation and addition of stem fibers (bamboo, rice straw), Chinese paper does not have the strength, suppleness, and thinness of Japanese papers from the same plants.

2. Inherent Problems

a. Manufacture: Generally, current standards of papermaking in China are low. Sulfurous acid (H_2SO_3) is used in pulping liquors, sodium hypochlorite (NaOCl) in bleaching, and the size contains aluminum sulfate. All leave damaging residues which can cause yellowness, fragility, and eventual crumbling. Some mills still produce calligraphy paper (xuan zhi) by traditional methods (Zhou 1988, 19).

b. Presentation: Traditional Chinese paintings were produced on a laminated structure to give "strength and body" to the smooth, fine, thin, light paper used as the support.

Manuscript and early printed scrolls: Mounted in the 1960s and 1970s in the West in the manner of oriental paintings, although mounting was not a traditional format (scrolls formed part of a library, not a collection of paintings). Lining and rolling was an easy option. Lined, rolled objects inevitably crack or delaminate because of the tension between the lining and the primary support. Type of method of manufacture, diameter of roll and thickness of paper and adhesive are also contributing factors.

3. **Treatment Observations**
See **4.4.3 A. Japanese Papers** for other notes on unlaminated objects.

C. **Near Eastern and Indian Paper**

1. **General Description**
There are few historical sources for the manufacture of Near Eastern and Indian papers available to English speaking paper historians. Historically, papermaking came to the West through trade routes from China via the Near East and India, so many of the traditional techniques and fibers used are similar to those used in Western papermaking.

Near Eastern and Indian papers use a great variety of fibers including linen, hemp, bamboo, jute, cotton, other bast and leaf fibers, and sometimes silk. Both Near Eastern and Indian paper often contain quite a number of small, colored inclusions such as hair and colored threads.

Historically, Near Eastern paper is composed of bast fibers from flax. The few technical studies which have been made of Near Eastern paper have found mostly flax and hemp fibers. The flax comes from both rags and raw fibers, including bits of bark. Rags appear to have been the preferred fiber source. The hemp is probably recycled cordage (Snyder 1988, 425-440). "Each fiber type might be used exclusively as a raw material or they might be mixed together" (Bosch and Petherbridge 1981, 28).

The fibers were washed, subjected to alkaline solutions and other treatments to remove impurities and to reduce them to a workable state mechanically or by fermentation (Bosch and Petherbridge 1981, 28). They are beaten to produce the pulp or stock from which the paper is actually made.

The paper is often tinted a light brown or sometimes blue, green, red, or yellow. It is often sized, the most common size being starch or a mixture of chalk and starch. Other sizing materials mentioned in contemporary accounts are gum arabic, gum tragacanth, starch dissolved in the soaking water of old straw, egg white diluted with vitriol, white fish glue dissolved in water, the clarified mucus of fleawort seeds, sweet melon juice, the liquid of cucumber and muskmelon seeds, molasses of seedless grapes, and non-oily rice paste. After sizing, the paper is polished with burnishers made of glass, shell, mother-of-pearl, or stone to make a smooth surface for calligraphy and painting.

There is some evidence that papermaking was practiced in Himalayan India by the sixth century A.D. Manufacture may have been localized because suitable plant sources for papermaking fibers grew mostly in the Himalayas (Losty 1982, 11).

Papermaking was introduced into the Islamic world in the eighth century A.D. (704, 712, 751 are suggested dates) (Bosch and Petherbridge 1981, 26). The Arabs knew of paper via trade before this time. "The new writing material soon gained prestige and popularity and quite rapidly became preferred to papyrus and parchment..." (Bosch and Petherbridge 1981, 26).

Papermaking was practiced in Nepal from at least the twelfth century. Nepalese papers all used the bark of the local daphne as the raw vegetable material (Losty 1982, 11).

From the eleventh to the fifteenth centuries Near Eastern paper was exported to the Byzantine Empire and Europe. In the fifteenth century, however, the tide turned and the Ottoman empire began to import paper from Europe.

From early times, India has also used cotton fabric in various formats (e.g., accordion folded, laminated into boards, and scrolls) as supports for letters and manuscripts. The fabric was coated with a flour paste, dried, and smoothed. "Sometimes cotton was treated so ingeniously that it created the impression of an entirely different material" (Gaur 1979, 27).

2. **Inherent Problems**
The addition of the coating of starch and burnishing makes Indian and Middle Eastern papers difficult to treat. See **4.4.2 J. Coated Papers.**

3. **Treatment Observations**

   a. Often Indian and Middle Eastern papers are laminates or cut-outs of various pieces of paper adhered together with a very fine overlap. The structure should be studied very carefully before treatment.

   b. The introduction of moisture in treatment should be approached cautiously. Tidelines are a constant problem and can be very difficult to remove. For the same reason other Asian papers with starch fillers are difficult to treat.

   c. Using alcohol locally causes starch size to turn grey which is impossible to remove.

4.4.4 Composite Structures

A. Collé Paper

1. **General Information**
The image-bearing layer, a fine delicate paper trimmed smaller than the plate to be printed, was adhered to a thicker soft-sized plate paper during the printing process. The two layers were adhered by a sprinkle of dry starch on the verso of the damp tissue (19th century), by starch paste (20th century), and most recently, by commercial pastes (1940s?). Apparently, the prepasted and dried paper was placed on the inked metal plate, paste side up. Damp, relaxed plate paper was then placed on top and the three layers (printing plate and plate paper) were pressed together through the press.

A variety of papers were used in the collé process. From the 1750s to the 1830s paper was made from bamboo and mitsumata fibers by the Japanese in imitation of Chinese calligraphy paper (this paper is now more correctly called China paper); it was introduced to Europe as wrapping/packing paper and adapted for use in line engraving, particularly for steel engravings. European or "Mock India" papers were introduced in the 1830s and Bible paper in the mid-nineteenth century (see

4.4.3 A. Japanese Papers, especially Gasenshi and **4.4.2 P. Artists' Printing Papers - e. India Paper**). Collé or laid Western papers are also encountered in 19th and 20th century prints (e.g., French artists, nineteenth century American historical prints, and prints by Kuniyoshi).(KN) The collé paper sometimes was chosen to blend with the color of the plate paper, sometimes to contrast with it.(CS)

2. **Inherent Problems**

   a. Plate paper is porous and often prone to foxing and water stains.

3. **Treatment Observations**

   a. During aqueous treatments the collé paper layer may separate partially (discrete scattered bubbles, along edges, or at corners) or completely from the plate paper. However, there may be strong physical attachment at heavily printed areas; use caution when attempting to completely detach the collé paper. Impression quality on chine can be compromised during aqueous treatments.

   b. Use a suction table to control aqueous treatments and discourage separation. Use damp blotters and webbing supports to pull out the staining without separating the two layers.

   c. If there is no indication that delamination will occur, float washing may be used. Have the suction table set up in case it is needed. To reflatten bubbles that may appear, remove the print from the bath and leave it on blotters until the collé is almost dry. Have on hand a dilute solution of cellulose ether. Encourage the bubbles to dry more quickly than the collé paper around them by touching their tops with the soft edge of torn blotter scraps. As they dry, they will grow smaller. Do not allow the perimeter to dry completely if there is still height to the bubble. If necessary, brush a little water around the bubble's edges to keep the deformation soft and rounded. Avoid linear drying patterns, like "ledges." When the bubble has only the faintest degree of moisture left and has almost shrunk completely, brush on a tiny bit of dryish cellulose ether, wait for further shrinkage and less adhesive tack and then tap into position with the rounded edge of a warm tacking iron. This technique eliminates the bubbles in the majority of cases. Occasionally, a bubble will not shrink enough to be tapped into place without creating wrinkles. In these cases, puncture the top center of the bubble with a titanium microscopy needle - with the fibers damper than for the other technique, so the puncture will be ragged - and continue as described.(CS)

d. Readhesion may be complicated by the fragility of the thin pressed paper, the differences in dimensional responses to moisture, and on the need for precise registration. Supporting the wet chine on Mylar may assist in realignment.(NA) For reapplication of a lifted tissue, use a Mylar carrier and raking light. Have both papers and the adhesive as dry as possible. Starch paste or other adhesives can be used.(CS)

Sometimes text overlaps the join line between papers and often there is a distinct outline of the collé paper on the plate paper, so misalignment will be very obvious.(KN) Impressions on both papers may be impossible to match.

B. Papier Marouflage

1. General Description

Historically, oversize posters, maps, and embrittled works of art were mounted to cloth linings during manufacture or subsequently by framers and restorers. This was often done to emulate paintings on canvas and increase the cost of drawings or as a solution for handling large works. Canvas-lined drawings are sometimes attached to stretchers and exhibited unglazed. Historically, some drawing papers were mounted onto cloth before execution of the artwork. For example, pastels by Mary Cassatt exhibit her stamp on the canvas.(LP) Posters were often routinely lined to make them easier to handle.(KDB)

Architectural presentation drawings were sometimes executed on watercolor or drawing papers which were mounted to fabric in the studio or purchased already mounted. The latter may have been available as early as 1885/1890. Visual evidence, in the form of regular striations caused by the pasting machine, may be helpful in identifying premounted sheets (Sugarman 1986, 45).

Contemporary artists often choose canvas mounting as a desirable way to present oversize drawings and exhibit without glazing. For some, mounting represents a conscious aesthetic choice. Works are usually mounted to linen after execution by professional mounters, often using glue-paste, starch adhesives, or synthetic adhesives.

2. **Inherent Problems**

   a. Use of incorrect methods and/or materials in the initial mounting may cause planar deformation, wrinkling, uneven attachment/separation, discoloration, etc.

   b. Objects were often lined with the intention that it would enable easy rolling. Often they were rolled image inward to protect the image. Consequently, this caused compression, cracking, etc. of the paper and media.(KDB)

   c. Differences in structure and method of manufacture and preparation may cause the paper and canvas to react to atmospheric changes and exposure to liquids and solvents in opposite ways (e.g., mechanical stresses, shearing and loss of adhesion).

   d. Stretcher/strainer mountings subject the object to more risk of physical damage by puncture, shock that leads to cracking in heavy paint layers, drawing at corners and deterioration of tacking edges.(CS)

   e. Physical and chemical characteristics of the attaching adhesive represent a further complication - adverse effects of aging/deteriorating adhesive (e.g., yellowing, staining, embrittlement, and decreasing reversibilities).

   f. Aesthetic surface changes in paper tone, texture, and flexibility associated with fabric and/or adhesive.

3. **Treatment Observations**

   a. Conservation treatments of contemporary works mounted to canvas should acknowledge the aesthetic significance of the artist's original mount. Consultation with the artist, curators, and/or art historians may be required before treatment.

   b. One option for retaining the historic format of a cloth lining while providing a more compatible and reversible support for a treated object is to provide a separating layer of Japanese paper such as tengujo between the object and the cloth (van der Reyden 1988).

c. If the object is on a stretcher/strainer, one should attach a Tycore or corrugated board filler to protect the exposed back.(CS)

d. Replacement of a strainer with a rigid, chemically stable support of the same dimensions is often appropriate for items mounted on a strainer. An attempt to flatten tacking edge can cause distortion in image area.(LP)

C. Compound Drawings

1. General Description

These drawings are usually mounted by the artist or collector to a "secondary" support which conveys both aesthetic and/or historical information. Thus, the secondary support is an integral part of the work with historic significance and should be retained.

For example, Paul Klee systematically mounted his drawings on paper to stiff cardstock; his secondary supports are important aesthetically, as informational devices, the official presentation format, and as examples of the artist's thrift (for more information see Schulte, Ellis, and King 1986, 20-23). For Klee's drawings there were generally two methods of attachment: spot attachment by random or regularly spaced adhesive daubs; and overall mounting with adhesive.

Degas employed several systems for mounting. (See Chandler 1984, 443-448.)

Old master European drawings were often mounted on decorated mounts which complement the drawing and form an aesthetic whole. They may bear collector's marks or inscriptions which help establish provenance. For example, Vasari had a mount designed for his personal collection and Glomy in the 18th century decorated mounts which bear his name or "G" blind-stamped at a corner.(KN)

2. Inherent Problems

a. Spot attached drawings may not lie flat. Some undulation may be expected and may not interfere with an appreciation of the drawing, but draws may be exaggerated and distortions can occur around each adhesive daub. Extreme tensions have been observed to shear and delaminate the paper (on the verso) around the daubs.

b. Drawings mounted overall tend to remain in plane with their secondary support, but may suffer from lifting or bubbling.

c. In addition, compound drawings may suffer disfigurement from glues, tapes, and framers' notations; from having been cut down or folded to fit into smaller frames; from removal and disposal of the secondary supports.

d. Historical mounts may suffer from every sort of chemical, physical, and/or biological deterioration that the primary support is subject to.

e. Adhesives can cause staining.

3. **Treatment Observations**

a. Releasing primary from the secondary support may be desired if there is physical damage, extremely disfiguring distortions caused by tensions in spot attachment, the adhesive is expected to cause stains or acid damage over time, or the primary support is very delicate or weak and has not yet, but could, become drawn or deteriorated.

In making this decision, the conservator should consider the stability of the environment in which the object will be housed and the ability to monitor changes in the object. In excellent housing and environmental conditions and with the ability to monitor the object, a conservator may choose not to alter artist's mounting methods. In the case of the Klee drawings it was decided to retain the overall character of the sheet as well as evidence of past attachment by the artist (for more discussion on this particular case see Schulte, Ellis, and King 1986, 27-28).

b. If possible, reattach (or readhere) any delaminated areas using paste alone or with Japanese tissue hinges of appropriate weight.

c. Reattach to the original secondary support using hinges. Hinge along all four edges over an isolating layer of lightly buffered Japanese paper (also hinged to the mat) if this is required for isolation from poor quality materials.

d. If possible, use ragboard lined Plexiglas spacers rather than an overlay window mat to isolate the work from the glazing. This best presents the original mounted format for exhibition.

D. Collage

1. General Description

Collage can be composed of various paper and non-paper materials and of adhesives of varying quality and stability. As with other composite structures, decisions must be made as to when intervention is appropriate. Often the artist, particularly the 20th century artist, may have consciously chosen (or chosen to ignore the problems of) materials which are not stable.(NA)

2. Inherent Problems

In the case of collage materials, pieces can become individually damaged or cause damage to each other (see King 1978).

3. Treatment Observations

a. If disassembly of a collage is necessary, document the object and its various parts with tracings as well as with photographs before beginning treatment. Mark every shape and have a style of marking to designate support areas versus applied areas. If appropriate, make notes along joint lines about overlap or anything else one may forget over the course of a long treatment. Collages may have applied pieces completely hidden by upper layers (e.g., R. Motherwell). Photograph extensively during disassembly of multi-layers of objects, to facilitate the study of the artist's process by art historians and others.(CS)

b. Depending on the media involved, attachments can be held in place during washing by facing with lightweight Japanese paper and methyl cellulose. The methyl cellulose will not release during warm water washing but can be removed afterward with cool water applied with a swab.(DvdR)

c. In C. Oldenburg collages, conspicuous masking tape tabs were used to adhere collage papers to the support. In one example, the masking tape was discolored and detaching and with the consent of the curator, the masking tape was removed and solvent used to remove adhesive from the carrier. The carrier was lined with thin Japanese tissue and wheat starch paste and readhered in the original position.(NA)

E. Restrained Papers

1. General Description

Papers attached to strainers, rigid backings or false margins "inlaid." Mounting may occur before or after execution of the work, either by the artist, a framer, or by some other person. Papers may be mounted to facilitate handling and display; provide support for weak or especially large papers; mimic the presentation of paintings; and, among contemporary artists, for aesthetic reasons.

a. Strainers: Usually the primary support is not attached directly to the strainer but is first mounted to a secondary support of paper or cloth, or to a false margin. The edges of the secondary support may be directly adhered to the face of the strainer. More often, however, the secondary support extends beyond the primary support and is folded around the outside edges of the strainer where it is attached with an adhesive and/or mechanical fasteners (tacks, staples, nails). Sometimes the edges of the work of art itself are folded around the strainer. If the secondary and primary support have been dampened before being attached to the strainer they will have shrunk upon drying and may be under tension.

b. Rigid backings: The primary support is adhered overall, along its edges or by random or regularly spaced spots of adhesive to a rigid secondary support. This rigid backing may be of wood, masonite, cardboard, glass, plastic, or sheet metal or it may be a panel constructed of one or more materials (e.g., aluminum honeycomb panel with wooden spacers at edges).

c. False margin: The primary support is inlaid into a false margin of paper which slightly overlaps its edges. Ideally the join is achieved using the thinnest of pared margins (approximately 3-4 mm), but sometimes broad and/or unpaired margins occur. A false margin may be added to facilitate handling; control curl of a work that tends to roll up, usually after removal of a previous lining; and reestablish original format, for presentation.

2. Inherent Problems

a. Strainers: Papers are easily punctured, especially as the secondary and/or primary supports deteriorate, becoming weak and brittle. Breaks or tears in the edges of the secondary support may result in uneven tension and planar distortion of the primary support. Delamination of primary and secondary support (which may occur due to environmental conditions or poor materials and technique of fabrication) can also cause uneven tension and planar distortion. Papers may split due to dimensional changes of the secondary support or strainer. There may be some tendency of paper to distort by sagging into the opening of the strainer.

In cases where the edges of the primary support have been folded around the strainer they may be damaged by tacks, nails or staples. Heavy corrosion deposits may exist at these spots. Stress on folded edges may cause rupture of paper fibers, cracking of the paper and flaking of the media. Later attempts to flatten these borders can exacerbate these problems. Abrasion of the folded edges may occur, especially as the work is slid in and out of a frame. A commonly encountered adhesive is animal skin glue. Unfortunately, more often than not, it remains voraciously strong.(CS)

b. Rigid backings: Wood, masonite and cardboard panels may warp, placing the work under tension, or they may split or snap. Plastic and metal sheets may be bent or dented and glass may break. Any rigid backing to which a work is adhered overall can harden and flatten the surface texture of the laid lines, felt marks, platemarks, etc. If the work is adhered around the edges or at intermittent spots, it will undergo stress as the secondary support and the restrained and unrestrained areas of the primary support respond differently to fluctuating environmental conditions.

c. False margins: Differing dimensional stabilities of the primary support and the paper into which it is inset, as well as the restraining action of adhesive layer, can cause pronounced draws or cockling. Wide or unbevelled margins which are visually incompatible may be aesthetically unpleasing. When unskillfully done "ledges" are frequently permanently pressed into the original work where the false margin overlaps it.(TF) While some view the use of false margins as a measure of protection for the edges of the work (especially one which is frequently handled) others may see extending a drawing with false margins as a violation of the integrity of the object

(McAusland and Stevens 1979, 33) and as further stressing often fragile edges.(NA)

d. Sometimes works on paper were "drum mounted," that is wet out, humidified, or in some way expanded with moisture and then laid down at the edges. This, upon drying, kept the work very flat. A puncture or sudden fluctuation in RH can release tensions developed by drum mounting. Also in treatment, releasing one edge or corner could set up tension which could cause a tear or crease.(KDB)

e. Contact with poor-quality adhesives and secondary supports may cause acid-transfer to and deterioration of the secondary support. Adhesives can stain papers, can penetrate them to locally change their inherent physical and chemical characteristics and may become irreversible.

3. **Treatment Observations**

a. Strainers: Papers adhered to strainers may be protected against puncture by fixing a rigid backing to the reverse of the strainer and by proper framing under glass or Plexiglas. If the poor quality of the mounting materials or the deteriorating condition of the work warrant removal from the strainer, treatment options may include the following.

1) Mimic original "stretched" presentation by removing primary and secondary support from strainer, removing and replacing secondary support if necessary, and then remounting the work on to a stable rigid panel of the same exterior dimensions and thickness as the original strainer. This mounting method would eliminate the danger of puncture. The solid support may be a laminate of several materials including acid-free mat board and corrugated board, paper honeycomb (e.g., Tycore), aluminum panels and aluminum honeycomb. The secondary support may be adhered to the panel only where its edges wrap around the solid support or overall by means of an interleaf layer (e.g., Hollytex, Japanese tissue, etc.) which will permit its easy separation from the solid support. Japanese paper hinges can also be attached to the edges of the primary support and to the back of the new support.(NA) If the strainer is integral to the history of the work, it can be

incorporated into the mounting and framing or stored separately (the latter choice often being less desirable).(CS)

2) Present the work flat by removing it from the strainer and, if necessary, from the secondary support. If the edges of the work have been folded around the strainer they may require humidification and flattening. Flattening may be complicated if the paper has stretched by "sagging" into the opening of the strainer.(NA) The artistic and historical significance of the strainer mount should be considered in determining whether or not the work should be presented flat. If the object is housed in a frame believed to be original, flat presentation should not be undertaken.(CS)

b. Rigid backings: Backing removal is often necessary, either to reduce mechanical and chemical threats to the work or to return the work to its original, loose-sheet configuration. Aqueous treatment may help bring back flattened surface texture. (See AIC/BPG/PCC **24. Backing Removal** 1985.) If the strainer is to be reincorporated into a treated object, the object can be protected from the acids within the wood by sealing the wood. Polyester film and Japanese paper, among other things, can be used as isolating layers (van der Reyden 1988).

c. False margins: After the removal of false margins light adhesive residues can still cause slight distortion of the edges. Removal of a false margin that was applied to control curl still leaves the problem of flattening which is compounded by perimeter adhesive residues.

4.4.5 Over-Sized/Three-Dimensional/Unusual Shapes

A. Over-Sized Papers

1. General Description

Large-sized and non-traditional materials and presentation of many contemporary drawings challenge traditional definitions of drawing. These objects now function as independent works of art whereas previously they more often served as preliminary steps in the evolution of more monumental works. Curatorial departments in museums frequently classify drawings exceeding 32 by 40 inches as over-sized (Volent 1989, 30-31). (See also **4.4.4 B. Papier Marouflage**).

a. **Single sheet:** Wide rolls of paper have been commercially available since the early 1880s. Artists today may make use of over-sized rolls and sheets which are available in a variety of fiber qualities, surface textures, etc.

Western paper (machine made)

- Arches watercolor - 44 1/2 inches by 10 yards;
- 100% rag barrier - 80 inches by 20 yards;
- Rives BFK 100% rag - 41 inches by 100 yards;
- Tableau (Technical Papers, Boston), abaca fiber (For example, oversize Leonard Baskin woodblocks prints [Man of Peace, 1952] were made on Tableau paper.)

Western paper (handmade)

- Emperor Sheets - 72 inches by 48 inches (Volent 1989, 30-31).

Japanese paper (machine made)

- Machine made papers are available in rolls 100 cm x 6100 cm;
- Handmade paper 60-70 cm x 100 cm;
- Paper Nao sells several Japanese roll papers in varying weights.

The relative unavailability and expense of good quality, over-sized papers or ignorance of the quality of the papers may lead students and established artists to rely on poor quality materials such as acidic photographic backdrop paper (initial pH 4.5) and impermanent industrial packaging papers. However, a paper that is chemically of poor quality might still be aesthetically pleasing to an artist. The initial use of the paper (i.e., packing or industrial use) might have a significance to the artist which a "good quality" paper may not have. Artists may also make their own over-sized papers (Volent 1989, 31).

b. **Multi-sheet supports:** Over-sized works may also be composite works, regularly or irregularly composed of smaller sheets of similar or varied paper types, variously joined (e.g., butt joins, overlapping joins).

2. **Inherent Problems**

a. The logistics of transportation, storage, exhibition, photo documentation, etc. require thorough planning.

b. During manipulation for conservation treatments, transport, storage and display, large-sized papers are particularly vulnerable to mechanical damage. To treat large items, experience as well as adequate space, equipment, materials, and staff are needed. Even basic treatment procedures are complicated by an object's large size and problems which may occur are likewise further intensified.

c. Presentation: Factors to consider include the limited availability and high cost of over-sized archival materials and, when available, their inherent physical limitations because of their large size (e.g., buckling of over-sized ragboards, heaviness of large glass sheets, warping of over-sized Plexiglas sheets, etc.) and, finally, the desire of artists to exhibit drawings in the manner of monumental paintings on canvas (Volent 1989, 31). Many contemporary artists may not want works on paper to be glazed in any way, even during travelling exhibitions.(KDB) (See AIC/BPG/PCC **40. Matting and Framing** 1988, 36.)

d. Storage: If possible, "Oversized works of art on paper should be framed as soon as possible to prevent damage and deterioration" (Volent 1989, 34). Horizontal storage is sometimes the only feasible system. Note, however, that it can lead to flattening and transfer of media and to permanent cockling and curling of the support. Rolled storage on a large roll or Sonotube can be a useful tool to facilitate handling. Rolling is not recommended as a technique of storage although it has been used successfully in certain problematic situations (Potje 1988). If rolling is to be used, roll the object face out.(EW) Over-sized objects, such as posters, may be encapsulated in polyester film and then hung vertically using various methods and devices.

e. Multi-sheet Supports: Non-alignment of grain directions causes planar distortions: the degree to which the natural grain directions, characteristic of some of these works, are to be retained should be specified before conservation treatment is undertaken.

3. **Treatment Observations**

a. "Routine" conservation treatments may be complicated because conditions such as overall humidification and even pressure are difficult to achieve on a large scale, but they are possible. (See Albright and McClintock 1982; Eckmann 1985; Fairbrass 1986; Hamm 1988; Owen 1988.)

b. Historically, large posters, maps, etc., were routinely adhered to cloth linings (cloth was available in sufficiently large widths and lengths) during production or by framers or restorers. Today, the conservator may use machine made Japanese paper with its "limitless" length for greater ease in lining over-sized Western papers, especially machine made ones (extremely large blueprints, wallpaper, posters, mechanical drawings, etc.). (See Nicholson and Page 1988; AIC/BPG/PCC **29. Lining** 1988.)

c. A treatment plan should incorporate designs and specifications for mounts, storage, proper handling and future transport, and display so that the work will be protected against new problems. This may involve consultation with the artist, curator, art historians, etc. (See AIC/BPG/PCC **40. Matting and Framing** 1988.)

d. Multi-sheet supports: Careful inspection of joints may reveal that the piece was misaligned when made; was disassembled, trimmed and rejoined; or that pieces of different images were joined.(CS)

Some conservators advocate separating composite objects at the seam(s) and treating each section. However, detaching the overlaps of a multi-sheet support can be very risky because of differential expansion of loose versus edge-bound paper. It is difficult to predict new dimensions/alignment after detachment. General recommendations to disassemble or not are difficult to make. Each object must be individually assessed through thorough examination and testing. (For a successful treatment see Hamm 1988.)

B. Fans

1. General Description

Fans present special conservation problems because they are three-dimensional objects designed for use and made of a combination of materials. They may vary from simple screen fans (see below) to mechanically complex folding fans. A third type, the folding "brisé" fan, has no paper leaf and will not be considered here. It is important to understand the structure in order to recognize causes of deterioration and to choose appropriate conservation methods.

Structure:

Leaf: May be made of paper or skin. (Leaves of silk and other fabrics fall under the domain of the textile conservator and will not be considered here.) Folding fans were most often composed of two semi-circular leaves pasted together on either side of ribs. Single leaf paper fans are less common. Screen fans consisted of a rigid leaf (of jade, ivory, etc., which will not be considered here) or a flexible material stretched over a shaped wooden frame and then attached to a handle.

Paper: Chinese fans were made from mulberry paper or shorter fibered papers. The leaves of Japanese fans were made of several sheets of laminated gampi. Western fans were made of antique or modern laid paper or wove paper; a paper imitation of skin, called "chicken skin" was also common.

Skin: Range of types, qualities and finishes were used.

Decoration: Painted or printed, with appliques of many materials.

Sticks or Handle: In folding fans the visible, often decorated, parts of sticks terminate in the narrow and more fragile ribs which are inserted between the two leaves. Sticks are held together at the base by a rivet. Heavier guard sticks, to which two free ends of leaves are pasted, strengthen the fan when in use and protect it when closed. In stretched leaf or screen fans, a handle was fixed to the screen with a small nail or rivet. Handle or sticks could be made of many materials, including ivory, tortoise shell (genuine and imitation), bone or wood.

2. **Inherent Problems**

a. Causes of deterioration: Natural aging of component materials is often accelerated by poor environmental conditions and acidic storage materials, such as custom-made wood or cardboard boxes. Combined use of various materials with different reactions to temperature and humidity changes causes many problems. Sticks over time become brittle, leaves less flexible and adhesives may either dry out or, in the case of fish glue, soften in excessive temperatures. Sticks are made of materials with grain structure which, especially due to their thinness, makes them prone to shrinkage and warping. Damage to the sticks results in damage to the leaves, since the leaves are subjected to increased stress with less mechanical support. (Damage to sticks will not be considered further since it falls into the area of the objects conservator.)

b. Use: As costume accessories, fans were subjected to constant manipulation, resulting in breaks, losses, tears and abrasion along the folds. They also suffered from exposure to light, dust, candle soot and other grime, oil from skin or foods, and many other deleterious conditions. As objects for collection they were again exposed to light and dust, and were often stored open, making them more susceptible to warping and sometimes impossible to reclose.

c. Past repairs: Materials used in the past for repairing leaves included parchment, glassine tapes, stamp hinges, silk, pressure sensitive tapes, and various papers and adhesives. Repairs were usually made without an understanding of their mechanical effects. Past repairs were almost always applied to the surface of the leaf, rather than between its layers. Sometimes repairs were unsightly and concealed part of the decoration, and sometimes they added bulk, causing distortions and impeding flexibility of folding leaves. Some repairs have caused irreversible damage.

3. Treatment Observations

a. New repairs and fills are made after cleaning the leaves, consolidating media, removing accretions, various residues, and old repairs. Ideally, repairs to the mount should be made between the two layers of the leaves so they will be invisible and will not cover any design areas. It is sometimes possible to use moisture applied locally to separate the leaves at breaks in the folds and then insert repairs, or even to completely disassemble, repair and reassemble the fan. Often, however, the original materials are very brittle or the media is extremely water sensitive, making it necessary to make unobtrusive repairs on the verso of the mount. Potential repair materials include thin Japanese paper, wheat starch paste, or methyl cellulose or nylon gossamer or polyester web coated with a thermo-plastic or solvent-reactivated adhesive. Cleaning, repair, and replacement of missing sticks may be carried out by an objects conservator.

If possible, the rivet holding the sticks together should be removed so a folding fan can be opened for treatment. When this is not possible, treatment must be more limited. Simple repairs can be complicated by need for triangular supports under damaged areas and for finger pressing instead of weighting of repaired areas. It may be necessary to construct triangles of mat board faced with polyester web to support mounts which require repairs but cannot be opened out flat. Treatment of screen fans is less complex.

b. Exhibition: Fans are extremely vulnerable while on display. Exhibition mounting must ensure that they are not under tension (a flat or slightly angled display is generally safer than a vertical display) and that the weakest structural area, i.e., the folds in the paper leaf, are adequately supported. Fans left open and unsupported may be damaged by irreversible warping of the sticks and flattening of the leaf. Mounts should be ramped to follow the gradual rise of the sticks toward the guard on the right and may be pleated to support the folds. It may also be helpful to secure the sticks to the mount with, for example, an interlacing ribbon of polyester web, and provide a support for the head of the fan, where the sticks are rivetted together. Screen fans may also require specially designed mounts to protect and support them (Maxson 1986, 33-38).

c. Storage: If a fan is stored closed it will inevitably be subjected to the wear and tear of opening and closing whenever it is examined or displayed. Many conservators, however, feel this is less damaging than the irreversible warping of the sticks that often occurs during long term storage in the open position. Each fan should be considered individually. Closed storage is recommended unless precluded by extremely brittle leaves, flaking media, three-dimensional decorations (sequins, beads, etc.), extremely warped sticks and mounts, or repairs that prevent closing. To avoid abrasion at the folds, the closed fans, wrapped in acid-free tissue, can rest on their guards with padding material around them to keep them secure and correctly closed.

C. Screens (LP)

1. **General Description**
Japanese - Wooden grid covered with multiple layers of paper (see Toishi and Washizuka 1987; Koyano 1979). Western - see van der Reyden 1988.

2. **Inherent Problems**
Problems include hinge failure, punctures, tears and splits, distortion due to humidity fluctuation, media flaking, and cleavage between layers.

3. **Treatment Observations**
Major repairs should be undertaken by a specialist trained in screen and scroll mounting. Remedial repairs, consolidation of media, reattachment of layers, and mending of tears and punctures may be attempted if not too severe or structural. A portable suction disc has been used to pull sunken puncture areas into place.

D. Papier-Mâché

1. **General Description**
Many examples of papier-mâché are found dating from ancient China to modern time. The term "papier-mâché" is used to refer to two different materials. (See van der Reyden and Williams 1986.)

a. Literal definition: Paper macerated back into pulp and then cast or molded into a form. Popularized in Europe in the mid-eighteenth century for ornamenting architecture and furniture. (See **4.4.5 E. Cast or Molded Paper.**)

b. Popular definition: Strips of paper laminated with an adhesive. In Western culture, laminated papier-mâché became popular in mid-eighteenth century as a base for Japanware (imitation Oriental lacquer). Pieces of paper adhered together with flour paste or a mixture of paste and glue were pressed between boards or metal plates, drenched in linseed oil for waterproofing, and dried in a hot stove. The finished product could be treated like wood (sawing, dovetailing, and screwing was possible). In the mid-nineteenth century the paper panels were softened with steam and forced into metal molds in order to form the paper into a variety of objects (e.g., trays, architectural moldings, chairs). They were sometimes coated with a gesso ground and varnished after drying. The surface would later be smoothed with pumice and decorated with paint, gilding, or inlays. There are many contemporary patents for papier-mâché processes similar to nineteenth century techniques.

Other examples of laminated papier-mâché include objects for religious ceremonies found in many cultures (e.g., masks, Mexican piñata) and papier-mâché sculpture and reliefs made by contemporary artists. The latter may be adhered with any available modern adhesive and may have surface coatings of various paints, synthetic or natural resins, or waxes. Some contemporary artists combine the basic principle of laminated papier-mâché (strips of paper laminated with an adhesive) with folding, bending, and compressing the wet laminate or with peeling, scraping, or otherwise manipulating the dry surface. Some work with wet sheets of paper that they fuse using only pressure, with no additional adhesive. Under these conditions, long-fibered papers will fuse best.

2. **Inherent Problems**

Traditionally made papier-mâché articles should be kept in the same environmental conditions as wood since they share the same major problems – splitting and warping due to extreme fluctuations of relative humidity. In high relative humidities or with the application of moisture, varnished finishes are susceptible to bloom. With time the varnish darkens. Extreme care is necessary in treating varnished surfaces since the paint and gilding is often very vulnerable. In proximity to direct heat the surface may peel. Layers sometimes delaminate. Contemporary works may be less rigid and more "paper-like" and may require the environmental conditions generally recommended for works of art on paper.

3. **Treatment Observations**

a. Delaminating layers can be readhered with wheat starch paste or methyl cellulose.

b. Fills can be made using paper pulp mixed with dilute wheat starch paste or methyl cellulose.(LG)

E. **Cast or Molded Paper**

1. **General Description**

The recent revival of interest in hand papermaking accounts for the growth of interest in cast paper. Paper sculpture or relief is formed by pouring a thick, liquid pulp into a mold or over a low-relief shape, by dipping a substrate, such as string or strips of paper into the pulp or by applying paper pulp by hand to a mold or to a substrate that will remain part of the work.

2. **Inherent Problems**

The many variables which can affect the finished product produce many possibilities for inherent problems.

a. Pulp source: Cotton rag or linters are the most common fiber stock, either purchased as pre-processed blocks or sheets or pulped from rag paper or by the artist himself. Less conventional pulp sources include fabric remnants, plant materials, and miscellaneous papers such as brown paper bags or toilet paper. Some of the materials used may invite future attack by mold, bacteria, or insects. Cast shapes will be stronger if made of long fibers. Pre-processed cotton linters are sometimes insufficiently beaten. As a result the fibers may not be well fibrillated, inter-fiber bonding will be weak, and the finished work will have little strength. Repulping pre-formed papers also produces works with less strength because the fibers, already cut and beaten to make the sheet, are further shortened. Sometimes foreign elements such as glass, wire, etc. will be added to the pulp slurry. Their future degradation or mechanical interference with inter-fiber bonding can weaken the work.

b. Additives: Paints, dyes, dry pigments may be added at any stage, and can have varying degrees of stability. The same can be said for sizings, such as starch, gelatin, cellulose ethers, and commercial sizes (e.g., Aquapel, Hercon 40). Some sizings also cause vulnerability to mold, bacteria, and insects.

c. Water quality will affect the longevity of any paper support.

d. Pulping method: The Hollander beater will produce the best quality pulp. A kitchen blender will cut and not fibrillate the fibers, so the resulting work will have less strength. Preprocessed dried pulp is simply hydropulped (i.e., mixed with water in an agitator such as a modified washing machine). Variables in beating include: fiber to water ratio; beating speed and time; sharpness of beater blades and their proximity to the bed plate. The pulper, vat, and utensils can be sources of foreign materials, such as trace metal particles which can lead to rust and foxing.

e. Forming process: The two main methods are a) pouring pulp into a mold and b) forming a wetleaf upon a mold and then modifying the wetleaf on the mold or after couching. Examples of mold materials include tin, wire, plastic, latex rubber backed with a plaster mother mold, etc. A vacuum process may be used during casting. Coating preformed materials (e.g., string, paper strips) with paper pulp is another possibility. The mold or substrate may be another source of foreign materials such as trace metal particles.

f. Drying: Works may be restrained or allowed to warp during drying. This may affect their future response to humidity changes. Possible drying methods include air drying; pressing followed by air drying on a number of surfaces including felts, glass, wood, metal, or the mold itself; heating; vacuum drying.

g. Surface treatment: The dried work may be sanded, burnished, stamped, carved, painted, or coated with a varnish or acrylic medium. Other objects may be attached to the surface.

3. **Treatment Observations**

a. Conservation: Because of the great potential for inherent vice and the often limited treatment possibilities, external factors which may cause deterioration must be carefully controlled. Humidity must be kept low enough to prevent mold growth. A stable humidity level will help prevent the cockling and warping that may result from the different moisture sensitivities of the various materials combined in the work, and can minimize delamination to which discreet layers of different materials may be prone. The chosen humidity level must take into account the requirements of any non-cellulosic materials included in the work.

Possible treatments include surface cleaning; local stain removal using poultices; consolidation; and repair of mechanical damages. Mounting, matting and framing methods must provide adequate support and depth for the work. For example, stronger hinges of non-woven polyester with synthetic polymer adhesives and contoured backboards might provide the support that is needed.

F. Embossed Papers

1. General Description

Relief is formed when paper, under pressure, is made to conform to a depression in a printing plate. Usually achieved through an intaglio process, though occasionally by relief or planographic processes. Can be done with or without printing inks (i.e., blind embossing). Embossing effects are incidental to some printing techniques (e.g., platemarks; light embossing of most woodcuts due to pressure used to print the block).

History: Earliest known deliberate embossings are fifteenth century paper-covered wax seals and rare "sealprints" made by pressing dampened paper over a wooden relief. Mid-eighteenth century Japanese Ukiyo-e prints were embossed by burnishing areas of the paper over an inked or uninked concave block. At the same time in Europe embossed chiaroscuro woodcuts and wall papers were produced. In the early nineteenth century various commercial items, such as book covers and hats, were made by embossing paper. In the 1830s uninked areas of lithographic stones were scratched out to create embossed highlights. In the late nineteenth century, after learning of the embossed ukiyo-e prints, Europeans first looked at embossing in its own right as a way to create an image. Among their innovations were color lithographs embossed by a second printing over an uninked intaglio plate, the first blind embossed print, and the "gypsographic," made by printing on an inked or uninked molded plaster plate. Embossing was widely popularized among printmakers after World War II.

Popular contemporary embossing techniques.

a. Embossed lithographs and serigraphs: The dampened proof is run through an etching press over a relief or intaglio plate, or over another proof to which objects have been attached to give it texture.

b. Collagraph (which emerged in the late 1950s): The artist makes a collage of materials which serves as the plate. Color and texture are produced simultaneously, as the inked collage is run through an etching press.

2. **Inherent Problems**
Many variables affect the character of the embossing.

a. The plate: May be one of those mentioned above, or a less common type, such as cement, plaster, etc. With too much depth the stress can exceed the elasticity of the paper causing fibers to rupture and the paper to crack.

b. The press: The etching press provides the high pressure needed for most embossing, but some artists use hydraulic presses for very deep relief. Too much pressure can cause cracking due to excess stress on the paper.

c. The paper: Long-fibered papers are better able to undergo the plastic elongation needed to conform to the shape of the plate and retain embossing without bursting. Since the paper is dampened before embossing to take advantage of the increased plasticity and flexibility of the swollen cellulose fibers, the moisture sensitivity of the paper is important. Heavy papers generally produce better quality embossing and retain it better on drying. Handmade rag papers are better than machine made papers which have a stronger directional response to water.

3. **Treatment Observations**

a. With any treatment care must be taken not to damage or reduce the relief. Drying and flattening without flattening the embossing is problematic for printmakers, as well as conservators who have to consider this before undertaking any aqueous treatment. The dimensional stability of the paper may be a deciding factor in whether or not to treat the object. Sometimes embossed and unembossed areas of the same sheet will have very different dimensional responses to moisture. Some embossed prints require a great amount of moisture to relax and flatten all areas. Soft felts or blotters can be layered and "sculpted" to protect relief areas as the print is dried under pressure. A heavy embossed paper may be able to withstand, and may even require, a surprising amount of weight to flatten it. Conversely, to retain more delicate embossings it may be necessary to limit the use of flattening techniques until the work is almost dry. Stretch drying is a possibility but may reduce the embossing as the paper contracts. Another possibility is drying on the suction table, with relief areas masked out, if necessary, to prevent their contraction under vacuum pressure.

b. Repairs to embossed areas must be made with papers that are flexible enough to conform to the embossing. Mends can be held in place by finger pressure, while drying with wads of cotton covered with a non-woven polyester, or other malleable, absorbent materials.

c. Mounting, matting and framing must provide adequate support and depth.

G. Wallpaper (MH)

1. General Description

Early wallpapers were made from single sheets of handmade laid or wove paper which had been joined to create the desired length. Hand painting, stencilling and wood block printing were the most common early decorative methods. Later wallpapers were often created from machine made (continuous roll) paper with roll printing and silk screening as the common decorative methods. The paper pulp available for wallpaper varied in quality and could include remnants of rags (cotton and linen) as well as inclusions of colored fibers, silk, wool, and straw. With machine made paper the use of soft and hardwoods, processed in a variety of ways, became very common. Wallpapers originating in the East (like Chinese export wallpaper) may be of a plied construction and composed of a variety of Oriental fibers. For design media, one may encounter inks, watercolor, gouache, distemper, water- and oil-based mediums, organic and inorganic pigments, and natural and synthetic dyes. One may also encounter mica, metallic elements, embossing, flocking (chopped textile fibers adhered to paper) and glazes on wallpaper.

2. Inherent Problems

Damage to structural components (e.g., plaster) and secondary mounting materials as well as the wallpaper itself; media friability.

3. Treatment Observations

The type of damage will dictate if the wallpaper can be treated in situ or if removal is required. Treatments include plaster repairs, readhering cleavage between mounting layers, media consolidation, compensation, and rehanging/protection.

H. Globes

1. General Description

The heyday of terrestrial and celestial globes occurred from 1500 to 1850. During this time globes were usually constructed for use as scientific and mathematical instruments. Two graduated circles on the globe allowed it to be used as a practical working instrument – the meridian ring which runs through the poles and the horizon circle which passes around the Equator. Globes were constructed from a variety of materials such as gold, silver, glass, parchment, bond, and cloth. Generally, the globe sphere is hollow. Inside the shell there is often a single wooden rod connecting the North and South Poles; there is a metal pivot at each pole to which the shell is nailed. However, an x-radiograph of the sphere may reveal a complex internal structure of wooden ribs running from the Poles to a wooden ring at the Equator. Traditionally, shells were made of papier-mâché by pasting the paper scraps over a plaster form. Once the papier-mâché dried, the shell was cut around the Equator and the halves lifted away from the mold. The papier-mâché shell was covered with plaster and trimmed to the correct thickness using a semi-circular template. Shells were also formed of other materials, such as felted manilla fibers. To balance the globe, if necessary, a bag of lead shot was inserted inside the shell at the Equator before plastering.

This description deals with globes with paper gores on their outermost surface. The gores were sometimes cut and split to ease their application to the sphere. A circular section called a calotte was prepared to fit over each pole. The first printed maps appeared in the 1470s using copper and wood engraving techniques. A map was intaglio printed on the flat paper gores. The sections were then wetted and stretched down onto the globe. The number of paper gores used to cover the surface of a sphere ranged from 8 to 36, with 12 being the most common. Often the globe gores were given a protective coat of varnish.

The printed paper on the horizon circle was adhered to a thin layer of gesso and varnished. Usually, the gores and the horizon circle were sized before they were varnished.

2. Inherent Problems

The composite nature of globes, the hidden intricacies of their internal structures, their sizes if large, and their shape present unique problems. In addition, it was common practice to update and recover the gores because of their utilitarian function.

4. Support Problems, page 88

a. Mechanical damage: The surface of the globe gores becomes abraded if the sphere is inaccurately mounted in its stand or if the globe drops in its horizon ring. The internal wooden structure, papier-mâché and plaster components may warp and move, resulting in plaster cracks. Fractures radiate out from holes in the sphere, with associated losses of ground, paper, and design. It is not uncommon for the bag of lead shot inside the globe to burst. The paper surface on the horizon circle may also suffer from losses, discoloration and soiling.

b. Discoloration of the varnish layer: Dust settles directly on the Northern area of the globe. Therefore, the Southern Hemisphere is usually cleaner and has a tougher coat of varnish. The varnish layer and surface dirt may obscure information recorded on the globe gores.

c. Insect, microbial damage: The wood, paper, glue, and paste used to construct globes can become infested, including the inner wooden structure and the wooden stand resulting in losses of component materials and weakening of the globe's structure.

3. **Treatment Observations**

a. Examination: The construction and condition of both the external and internal components of the globe must be determined using established non-destructive methods. Directing an x-ray beam at different points of the sphere will provide information about the internal structure of the globe. Examination under ultra-violet fluorescent illumination will help identify the varnish layer, retouches, and patches. An infra-red vidicon imaging system can intensify surface information on the sphere that is hidden by a discolored varnish layer and surface soiling. Details about the maker, the construction location, and the date should be recorded. This information may be contained in the cartouche or nameplate on the sphere. The stand and any metal components should also be examined and described in the examination record. Refer to Baynes-Cope 1985; Lewis, Leanne, and Sumira 1988; Sumira 1989; and van der Reyden 1988.

b. Surface cleaning: It is essential to remove the globe from its horizon circle and meridian ring before cleaning. Brush the surface of the sphere with a soft brush followed by dry cleaning, wiping with a slightly dampened swab, or the application of a thick poultice of methyl cellulose. The materials used to color the globe gores and horizon circle, usually watercolors, may be extremely fugitive. Solvents, such as dilute ammonium hydroxide may help remove surface dirt and speed drying time. Dismantling and immersion of the globe gores in water is a drastic measure. Upon drying, the paper gores may shrink, thereby distorting the intended geographical distance. Repositioning the gores on the sphere requires great skill as they must be adhered accurately with a very slippery paste while they are saturated with moisture.

c. Varnish removal: It is preferable to remove varnish mechanically. If deteriorated and originally applied over size layer, the varnish will flake off cleanly when abraded with a scalpel edge or point. The varnish layer may sometimes be removed mechanically using a tool (e.g., a rounded orange stick – a manicurist's tool). This avoids the use of chemicals and can result in dramatic cleaning.(LP) Rapid acting solvents on a small swab of cotton wool should be used if a decision is made to remove the vanish layer in this way. The use of chemicals should be limited since rinsing opportunities are restricted while the gores are adhered to the sphere. It may not be possible to remove the varnish layer if the globe was varnished without sizing the paper support. Solvents may drive the surface dirt into the paper, staining the globe gores.

d. Reducing dents: It may be possible to apply moisture from within the sphere if a hole has occurred in the area of the dent. Unobtrusive dents may be left as is. Bridges constructed of aluminum mesh or fiberglass will support damaged areas on the inner papier-mâché shell.

e. Repair of damaged plaster: The damaged area should be allowed to dry out before starting to in-fill. Apply the filling material in several applications to speed the drying time. A base coat of dental plaster "Kaffir D" (10:1 with water) will minimize the amount of shrinkage (Leyshon 1988). An example of a plaster mix for filling damaged areas (resembling original composition of the plaster used for the Senex globes): 1 part rabbit skin glue gelatin; 9 parts kaolin (B.P.); 1 part finely precipitated chalk (pure calcium carbonate – can be varied with gypsum or French chalk). The mixture was applied hot and allowed to dry between each application. Sizing the final coat of plaster reduces its absorbency.

f. Repairs to internal structure (e.g., retrieving the lead shot bag and reconstructing the North and South Poles). See Baynes-Cope 1985.

g. Repair of damaged paper support: Repair missing areas with chamfered infills of paper similar to the original in thickness, density, color, translucency, chain and laid lines, and surface texture. More than one thickness of paper may be required for fills on different areas of the sphere. Old plaster is extremely porous. Applying an impervious layer to the plaster base may be required before the fill is adhered. Blot the repair with a soft absorbent blotting paper to reduce drying time.

h. Revarnishing: If a decision is made to revarnish the globe following treatment, tests must be conducted to identify a varnish which will be deposited only on the surface of the globe gores, thereby retaining reversibility and the refractive index of the paper (van der Reyden, 1988). The porosity of the paper must also be determined. Resizing of the gores is often necessary.

i. Display: A hemispheric dome structured out of ultraviolet filtering Plexiglas will help protect the globe. The dome can be fitted to the horizon ring (Leyshon 1988).

I. Boxes (EW)

1. **General Description**

Paper based boxes have been used to house items such as hats, books, and games. The basic construction of a box and its lid consists of laminated boards stitched or glued together and covered in the interior and exterior with a variety of papers. Some boxes are made from thick, stiff paper that was scored, folded, and glued to form an enclosure, such as a box for a deck of cards.

2. **Inherent Problems**

a. The quality of the board and paper used to construct these boxes is generally acidic and deteriorates over time under adverse environmental conditions. The boards themselves can warp and sag. Adhesives at the joins weaken and fail, and the boards become detached or are lost. If the boards were stitched together the threads can loosen and break. The papers on the interior and exterior can delaminate, crack along seams, and become abraded and stubbed from general use. Poor storage conditions also present the problems of surface dirt, insect accretions and water damage.

b. The artifacts in the box itself can also contribute to its overall condition. Boxes which have held heavy items suffer from loose or completely detached bottom boards. The action of removing and returning an item to its box can cause abrasions to both artifacts.

3. **Treatment Observations**

a. Conservation treatment: Boxes offer a unique challenge to paper conservators. Traditional methods of repair need to be modified to conform to the three dimensional shapes of these objects. Bulldog clips, clothespins, and small clamps can be used to hold tears and splits in place after mending. Smaller boxes can be wrapped with Teflon tape or Ace bandages to secure a mend or adhesive in place. Often with small boxes, a secondary support needs to be constructed and placed inside the box in order to provide additional support prior to wrapping. Losses can be inserted with a board similar in thickness to the original and covered with toned Japanese or Western paper as necessary. Mends or reinforcement may need to be placed on the interior and exterior in order to provide additional overall support to the box. Water damage may require inpainting since aqueous treatment can be difficult to carry out due to paper layers and the shape of the item.

b. Storage and display: Empty artifact boxes should be displayed and stored with an interior support which helps to maintain the box's shape and prevents the lid from sagging. This can be constructed from thin, acid-free board as a series of vertical, accordion folded strips or as a scored, folded, and taped open ended form. Boxes which hold artifacts can be stored on a secondary support of acid-free corrugated cardboard slightly larger than the dimensions of the box to allow for a hand hold. The box itself can be held in place by attaching twill tape to the underside of the secondary board and tying the tape over the box. Artifact boxes can also be placed within a custom-made or commercially made storage box.

J. Other Objects Made By Distortion of Planar Sheet

Scoring, folding, rolling, and curling are the basic methods by which the flat plane of a sheet of paper can be shaped into a three-dimensional form. Adhesives or fasteners may be used to keep the sheet in the distorted form.

1. General Description

Examples: Japanese origami; ritual paper facsimiles of clothing, household objects, etc., used in buddhist funeral rites; paper models for sculpture, engineering designs and architecture; foldouts in illustrations (e.g., books of hand-drawn landscape, theatre set and architectural designs containing fold-out elements to be considered as design options); puppets; lamp shades; contemporary works of art made by folding, bending, weaving, curling, and otherwise distorting paper; quilling.

Strength of the object is determined in part by the properties of the paper used. Paper folds and curls more easily along the grain. The density of fibers and how tightly they are compacted affects ease of compression for folding. Internal additives like fillers or sizes play a role in how paper responds to deformation, especially in bulky papers of low fiber density. Surface coatings can stiffen paper, making it resist folding or curling, and resulting in flaking of the coating. The tensile strength of the paper, an indication of how much the paper can stretch before it ruptures, is partially determined by fiber length. In general, longer fibered papers have greater tensile strength and fold endurance than short fibered papers because "...the wire side of the sheet inherently contains a slightly larger proportion of larger fibers to fine and a greater filler ratio than the felt side...less cracking at the fold is encountered when the stronger wire side of the sheet is kept to the outside fold area where more tension prevails" (Byers 1971, 104). Another factor is the stress to which the paper is subjected when curled or folded. In folding, the outer surface must cover a wider radius than the inner surface. It will be stretched under tension while the inner surface will be compressed. If the stress on the outer surface exceeds the elasticity of the paper, fibers will rupture and the paper will crack (Byers 1971, 104). Scoring reduces this problem by stretching or breaking fibers, thus reducing the number of fibers which must be bent. The strength of a folded paper object is also affected by the integral strength of the geometric form which has been constructed. When properly constructed, pyramid shapes like the cone and the equilateral triangle are the strongest geometric forms. The failure of adhesives and fasteners also contribute to the weakening of three-dimensional paper objects.

2. **Inherent Problems**

Deterioration of the object with aging is affected by environmental factors and all the inherent vices of its materials and construction, but can be especially devastating because the breakdown of the paper (or adhesive) can lead to the collapse of the three-dimensional structure. The three-dimensional construction may preclude, or at least complicate, more interventative treatments like washing and lining. Techniques may be borrowed from treatments used in textile conservation, such as the use of minisuction tables with shaped heads that can be inserted where needed for local washing or solvent treatment.

3. **Treatment Observations**

Display and storage: Among the standard considerations for works of art on paper, relative humidity deserves special attention. Embrittlement caused by low humidity may result in breaking at the folds or the areas which most support the weight of the object, while the increased flexibility that occurs in high humidity may result in sagging and sometimes collapse of the object. Even in the best of conditions structural support is often required, both in storage and display.

4.4.6 Traditional Non-Paper Supports

A. Papyrus

1. **General Description**

An writing support used primarily by the ancient Egyptians made of lengthwise strips cut from the soft, white inner pith of the Cyperus Papyrus L reed native to marshy areas of North Africa. Papyrus was used in the Mediterranean region from perhaps the fourth millennium B.C. to the twelfth century A.D. The fabrication technique was lost in the Middle Ages. Strips were probably soaked in water, rolled to soften, laid down to form an overlapping cross-laminated structure, then pressed to bond and dry. There are different theories about what bonds the strips together -added adhesive, natural sap, or physical adhesion. Formed sheets were pasted together to form long rolls. Ancient examples may be firm, smooth, flexible, and translucent and of a fine and even texture; modern products are often heavier and thicker.

2. **Inherent Problems**

a. Uncertainty about the manufacturing process presents problems: if starch paste was used in bonding then aqueous treatments could endanger the adhesion of the two layers forming the sheet.

b. Analysis has shown that proportions of the main constituents of papyrus (cellulose and lignin) vary with age, manufacturing process, and environmental effects. If well-made, properly housed, and cared for, papyrus can be a durable material which may be repeatedly rolled and unrolled over time. Eventually its flexibility diminishes; ancient papyrus may now be desiccated and brittle as well as discolored. It also has a strong tendency to curl up unless restrained. Edges fray easily. Nineteenth and twentieth century methods of handling, storage, and display often consisted of taping or gluing the papyrus to cloth, poor-quality cardboard, cellulose nitrate, hardened gelatin sheets, or clamping between sheets of glass in passe-partout. Acids have migrated from these materials into the papyrus. In addition, papyri within such mounts have fractured because of tensions between object and support in fluctuating atmospheric conditions (Elliott 1987, 64).

3. **Treatment Observations**

a. Alignment of fragments: Pronounced fibers of cross-laminate structure, obvious on a light table, may assist in positioning improperly placed fragments. Deteriorated papyrus may be so brittle that it is impossible to handle without dampening; however, its surface becomes tacky when wet. Nylon gossamer tissue is used as a work surface at the British Museum. Overall moistening is recommended to prevent formation of stains that occurs with local wetting; a solution of 1:1 industrial methylated spirits (IMS), (or ethanol or acetone), and water permits alignment of fibers, manipulation of distortions, removal of creases, etc.

b. Backing removal: Removal of fragile, brittle papyrus from poor quality secondary support is assisted by using a facing. Some poultices (cellulose ether, sodium carboxy methyl cellulose [SCMC]), damp blotter method or both have been used to remove backings, inlays, and old repairs. Scrape away residues in the direction of the papyrus fibers to avoid damage.

c. Aqueous treatments: Discolored and stained papyrus apparently responds well with no layer separation problems. In order to remove discoloration and acidity by washing, the sheets must be reasonably sound. Float washing on Mylar or between two sheets of nylon gossamer web is recommended; papyrus' natural buoyancy contraindicates immersion.

d. Repair: Papyrus has a strong tendency to return to the position it has been held in over a long period of time (e.g., rolled). At the British Museum, gluten-free wheat starch and Japanese paper were used to repair papyrus successfully on the light table.

Some papyrologists feel that repairs on literary texts and archival documents should be visible so that the origin of the texts' arrangement is clear. This will aid interpretation of the text. Before treatment photography is, of course, also helpful.(KDB)

e. Removal of acidity: pH of papyrus is acidic because of its relatively high lignin content (unless formerly buried in alkaline conditions).

f. At the Princeton Library, a papyrus mask from a mummy (dating from Ptolemaic times) was disassembled in order to ascertain presence of informative texts or documents. A Danish freeze/dry technique was used in which the object was soaked in an enzyme (to dissolve the adhesive) and then freeze-dried to remove the water and adhesive. In addition, some parts required steaming in order to release them.(KDB)

B. Palm Leaf

1. General Description

A most ancient support for writing and miniature painting, according to Pliny, palm leaf can be archaeologically documented back to the second century A.D. Palm leaf manuscripts preserve many unique sources of Indian, Nepalese, and Southeast Asian culture and religion. They continue to be used in the twentieth century. Preferred leaves are those from the Talipot and Palmyra palms which are plicate (i.e., having parallel folds) and segmented with a central rib. The hard, yet flexible flaps on either side of the rib yield the material that is prepared by drying and polishing for writing or painting or for incising characters using a metal stylus. Up to 400 leaves were, traditionally, laced together through pierced holes to form a "book."

2. **Inherent Problems**

   a. Palm leaf is very susceptible to desiccation by a hot, dry environment; it will lose flexibility and become brittle. The lignified cells are particularly susceptible to degradation and discoloration.

   b. When exposed to high RH conditions or actual wetting the leaves may stick together in solid blocks.

   c. Palm leaf has poor resistance to wear and tear; it is easily damaged by constant handling, especially at the edges which can fray.

   d. The leaf tends to split into long strips along the longitudinal veins, especially where incised previously with a stylus. Once begun, mechanical damage progresses through the leaf.

   e. Damage is caused by friction between the cord and the edge of the hole.

3. **Treatment Observations**

   a. Correct storage in a controlled environment is the best way to prevent damage to palm leaf manuscripts and should be designed to minimize the need for unnecessary handling. (See Lawson 1983 for current practices at the British Library.) To lessen effects of damage from lacing, the British Library strings the leaves into books using the left hole only.

   b. Palm leaf manuscripts with very small holes, there by tradition rather than for practical use, should not be strung.

C. **Parchment/Vellum**

1. **General Description** (JM)
Known since ancient times and used as a support for writing, painting, drawing and printing, it is made from the skins of

animals, especially goats, calves and sheep. The varieties differ in grain pattern, markings, fat content, thickness, color, and flexibility. Parchment is prepared from pelts (i.e., wet, unhaired and limed skins) simply by drying at ordinary temperatures under tension, most commonly on a wooden frame known as a stretching frame (Reed 1972, 119). The result is a stiff, flat, generally opaque sheet. The pelts are not irreversibly tanned with acids, the method used to make leather. Parchment is quite permanent and durable; capable of lasting thousands of years if kept in stable environmental conditions.

The terms vellum and parchment refer to skins which are prepared with lime in exactly the same way. They have had different specific meanings depending upon when and where they were made. The modern British definition of parchment refers to skins made from sheep; vellum to skins made from calf, goat or other animals. Vellum, in the past, has implied the fine, white skins used for the exquisite Books of Hours, but in modern times it is often used to imply bookbinding weight skins, leaving parchment to refer to the document weight skins. Yet, fine skins are still made from calf, and stiff, thick skins are made from sheep. Thus, the issue of precise terminology is somewhat confusing. Since it is so difficult to distinguish the animal used to make an early manuscript substrate, a prominent paleographer uses the term parchment for all animals when describing manuscript skins.

Hair and flesh sides are terms often used to describe parchment. The hair side (i.e., the outer or grain side of a skin) will often be gelatinous in look and smooth with a grain pattern or hair follicles occasionally visible. This is from the treatment of the skin and the shaving action of the knife. The flesh, or inner side, is usually much softer, more absorbent, with a loose, velvety appearance. When the hair side has been pumiced (pounced) in preparation for the ink, it is made velvety and thus it is difficult to distinguish hair from flesh sides. If the flesh side has been shaved with a knife and prepared to have a smooth finish, it is also difficult to tell hair and flesh sides apart. The flesh side is generally more receptive to humidity, so the skin will curl in the direction of the hair side.

Fabrication: One should become familiar with the preparation of parchment as a basis for understanding its working properties, sensitivities, and limitations. The basic methods used today are similar to those used in the Middle Ages, but the medieval techniques attained a perfection which has been progressively neglected since the sixteenth century. Parchment is made from dehaired, limed pelts which are dried at ordinary temperatures under tension and shaved with a semi-circular or lunar knife to desired finish. The wet, limed pelt is stretched on a frame to dry under tension which plays a critical part in the structure of parchment. The fiber network in any pelt is complex, with the fibers running in all directions, giving flexibility to leather. During the simultaneous stretching and drying process to make parchment, however, this fiber orientation is changed to be realigned into layers parallel to the flesh and grain surfaces of the pelt. This reorganization of fibers is set in this new and highly stretched form by drying the pelt fluid or ground substance (a mucous-type secretion) to a hard, glue-like condition. It is this realignment of fibers which produces a taut, stressed sheet which is relatively inelastic and has a stiff handle. It is also the distinguishing factor between parchment and leather, not merely the fact that leathers are tanned. Ancient pelts were sometimes processed into parchment and then also tanned (see Reed 1972 for more detail). In the West, the surface was sometimes prepared with chalk or similar material to increase opacity and absorbency. Some skins were also given a nappy surface for use with pastels, especially in the eighteenth century.(LP)

2. **Inherent Problems**

a. Parchment is a relatively stable material in that it is resistant to deterioration. It absorbs few sulfurous acidic pollutants and those it does tend to be absorbed by its natural alkalinity.

b. Parchment is very hygroscopic; a humid environment makes it swell, a dry atmosphere dehydrates it so that it shrinks and becomes stiff. It is the ground substance which is extremely reactive to humidity and can absorb water even after dried in the parchment. If parchment absorbs large amounts of water, the fiber network can relax since it is not constrained. When the fiber network system is dried in this new relaxed state, the parchment can become hard, horny, and cockled. Therefore, exercise extreme caution when storing or treating parchment. To retain the properties of parchment, any treatment involving humidity should also involve drying under tension to maintain the stressed, parallel alignment of fibers.

c. Dimensional changes in the parchment support caused by relative humidity fluctuations can create tensions in the parchment which can cause detachment of media.

d. High humidity levels will lead to microbial attack on parchment and consequent weakening and staining. It also enhances the usual chemical degradation reactions (e.g., excessively acid inks can transform the support into lacework) (Chahine 1989, 15).

e. Can be easily torn or cracked if the skin has suffered from deterioration, is thin, and/or the conditions are too dry with excessive stress.

f. Greek medieval (Byzantine) artists coated the finished parchment sheet with an egg-white preparation and polished it; this created a smooth, shiny surface from which media readily flakes (Abt and Fusco 1989, 61).

g. Often the same color as paper, very thin and flexible, though with a "solid" feel and a tough "body," parchment can easily be mistaken for a sturdy paper. Parchment's behavior and recommended care, however, are radically different from that of paper, because of the great differences in basic natural materials from which each is made. When parchment is mistaken for paper and subjected to certain paper conservation procedures, the results are disastrous (Ellis 1987). Parchment cannot be immersed in water, for instance, because the lime can be removed, and the skin can wrinkle and go transparent. Exposure to heat is disastrous as the skin can irreversibly shrink.

h. Since parchment is so hygroscopic, one can expect it to expand and contract with seasonal changes in RH and temperature. A certain amount of cockling in an item considered for treatment is not only inevitable but also aesthetically inherent. Concern must be given to cockles affecting media attachment. Traditional methods of hinging using paste and Japanese tissue can result in cockling around the hinge as the skin expands and contracts, while the pasted hinge area moves at a different rate. Hinging methods have included string matting (see Clarkson 1987, 201-209), suspending with Mylar tabs and applying the feathered fiber ends of Japanese paper strips all around the perimeter.

3. **Treatment Observations**
The methods used to treat parchment are based on those used to originally prepare it.

a. Surface cleaning: Use brushes, soft erasers, low suction vacuum, swabs, and a minimum amount of moisture. One must be very careful that eraser particles do not become trapped in the fibrous surface of the parchment, especially in areas where the surface is creased or abraded.

b. "Performing miracles on water-staining and grime can't really be expected since the skin cannot be immersed in water" (Munn 1989, 30). Use the least moisture possible to remove water-soluble adhesive residues. Try ethanol and water mixtures and work locally under the microscope. Use of the suction table may be effective for local stain removal as well as flattening.

c. Appearance of transparency in the course of conservation treatments, especially as a result of the application of water, water/alcohol, and urea solutions, lanolin, glycerol, excessive tension, etc. (Chahine 1989, 17-18).

d. Methods of repair should "aim to preserve the original character of the material by using methods related to the parchment-making process, in particular...hydration and tensioning" (Cains 1982/83, 15).

Water-damaged or distorted parchment may respond to humidification in a constant humidity chamber, on a damp pack of blotters through several layers of permeable polyester web or Gore-Tex, or overall applications of alcohol or alcohol/water solutions. "The advantage of the chamber method is that the hydration process is slow and one can determine the best conditioning point within a broad time scale"; timing with the pack system, particularly if the parchment is thin or there is a danger of offsetting, can be critical (Cains 1982/83, 16; Munn 1989, 31). With the pack there is a risk of transparency and/or excess water absorption.

Extra humidity may be applied to more severely affected, horny, or less absorbent local areas during overall humidification; use moist, not wet, blotter pieces over permeable polyester web on distorted areas or apply water/alcohol solutions locally. Water alone can darken parchment.

The appearance, opacity and surface texture of parchment can be altered during hydration and tensioning (Cains 1982/83, 15-16).

e. Flattening/Tensioning: Pressure methods of flattening do not preserve the original character of parchment nearly as well as tensioning which reflects the original parchment-making process (Cains 1982/83, 15). Tensioning "must restrain the skin while it is drying until the moment of reaching equilibrium when the skin comes under tension and is more or less flat." The relaxed condition of the humidified skin may lead to overstretching; with very distorted parchment, tensioning may be undertaken gradually in a series of steps (Cains 1982/83, 15-17). If dried too fast after humidification distortion may result.

   Poorly modified clips combined with high moisture content in the skin will produce indelible marks around its edges.

f. Applications of lubricants to shrunken material that does not respond to hydration and flattening (see Chahine 1989, 17-18).

g. When mending skin use only structurally similar materials (e.g., gelatin or parchment size for the adhesive, parchment and goldbeater's skin or fish skin membrane for the mending materials). This should prevent stresses resulting from different expansion/contraction rates which may cockle and tear the parchment.

h. Because of its extreme hygroscopicity it is essential to keep parchment in a stable environment: 18°C ±2° (64.4°F ±2°), 55% RH ±5% (Chahine 1989, 15). The benefits of flattening parchment can be largely negated by dry storage or exhibition. Maintain a micro-climate within exhibition cases that will conserve the equilibrium moisture content of the parchment, see, for example, Cains 1982/83, 21.

i. Media consolidation is frequently necessary. Use parchment size in various dilutions with water and ethanol or isopropanol. Apply locally with brush or spray when there is overall media friability. Press after spraying if possible.(LP)

D. Pith/Rice "Paper"

1. General Description

Soft, velvety, translucent, ivory colored, spongy, paper-like substance not made from rice and not true paper; pith of the Asiatic shrub, Chinese cottonwood (Tetrapanax papyrifera Hook Koch), native to hills of South China and Taiwan. A popular support for Chinese export watercolors from the 1820s on.

Technique of manufacture is described by Bell (1985, 109-117). For preservation purposes it is important to know that the "paper" is formed by cutting a rod of pith into a spiraling ribbon; these lengths are then pressed flat and trimmed into sheets. The sheet's grain direction is visually obvious. Aged pith ranges in color from stark white to cream to pale gray.(CS) Under the microscope pith "paper" appears to have a cellular, non-fibrous structure. Pith, the tissue in the center of the plant stem, is made up of large food storing and conducting cells (parenchyma and collenchyma) which are very responsive to moisture. This accounts for pith "paper's" receptivity to watercolor which is readily absorbed by its surface causing swelling and a permanent relief effect.

2. Inherent Problems

a. Pith "paper" is so fragile that pressure from a finger can create a permanent depression (seen frequently on these objects) and a finger nail easily slices it. Use a secondary support whenever possible to avoid direct contact. The porosity leads to easy discoloration by embedded dust, severe staining - even from materials applied to the back (e.g., original mounting adhesives). The appearance of the pith is such that tissue fills are very obvious. If scraps of pith are available for filling, be sure to match grain directions. Scraps of a different tone can be lightly brushed with dry pigment mixtures to improve color compatibility. Splits have often drawn apart, with resultant gaps.(CS)

b. Pith "paper" is quite flexible in humid air and can be stretched and molded when damp. Water and some organic solvents may make it temporarily transparent. Wetting or washing by immersion will expand the support permanently. It becomes more brittle with drying and even when new it has poor fold resistance. It may curl or crack with exposure to excessive heat. The fragile surface is easily damaged by abrasion and by uneven or excessive pressure. Pith "paper" becomes brittle with age, it cracks and tears easily when improperly handled or stored.

c. Presentation: Traditional presentation was by ribbon binding around all edges (most likely to protect against splitting) and then assembly of individual sheets into a bound volume (Purdue and Kraebel 1961, 177). In its original form, it is likely to be found mounted on album pages of good quality paper (Chinese/European). Poor-quality European secondary supports are likely to be of later origin. Often paintings are only tipped on or otherwise locally attached. Rapid expansion and contraction of sheets with humidity changes can lead to physical damage if they are restricted by glued areas and mounting methods.

3. **Treatment Observations**
(See also Rickmann 1988.)

a. The pith sheet's surface is very delicate and porous. Avoid removing surface deposits by brushing, this may embed mold or dirt. Do not use a scalpel to pop off accretions, this will only cause more problems.(CS)

b. It is very difficult to mend tears because of both translucency of the material and difficulty in manipulating it. F. Mowery's gossamer tissue (or as a second choice tengujo) impregnated with Klucel G and applied by rolling a dryish swab of ethanol over the tissue works well. To set: immediately place Teflon cloth over the swabbed tissue, press lightly with fingers and blow away the ethanol.(CS)

c. Pith sometimes shows foxing or glue staining. Stains can be successfully treated locally with water and blotting paper. Use of the vacuum suction table may not be safe because pith is so spongy, but with some sheets it can be used at very low suction.(CS) To a certain extent, strength and flexibility of pith "paper" is enhanced with wetting so aqueous methods of repair would seem to be the methods of choice. Yet, most conservators use only a minimum amount of moisture. This is because the pith paper tends to absorb water like a sponge; on these vividly painted objects at least one pigment always seems to be extremely prone to wicking upon exposure to water (as opposed to moisture vapor).(CS) Some conservators use methyl cellulose as adhesive to control water content during lining and mending.

d. Pith paper should not be lined unless it is very fragmented since puckering (and slight relief effect) of the support caused by the pigment layers is original. Since tears/splits have no overlap, and thus are difficult to repair successfully, lining is sometimes necessary. To avoid pressure on surface when a pith "paper" support must be lined and flattened, and to eliminate severe curl and tenting at cracks after lining, a modified "polyester lining" technique may be used. Sanded Mylar is taped to solid, flat surface. Woven polyester fabric is laid on Mylar, impregnated with very thin paste and stretched out evenly. Japanese paper is brushed out on fabric and allowed to dry. Lining paper is coated with thin layer of relatively viscous methyl cellulose, humidified pith "paper" is set on lining, gently aligned and allowed to dry. Then Mylar and polyester are each peeled off back without need to strain and crack pith "paper." More traditional methods using Japanese papers and wheat starch paste can also be successful. Make lining and presentation system sufficiently larger around edges to minimize exposure to handling.(CS) Minimum pressure must be used at all times or the pith surface becomes "dead" or flat. On the other hand, previous mounting or storage may leave the sheet quite compacted before it arrives for treatment. In such cases, controlling other factors may become more important.(CS)

e. When missing areas must be replaced only butt joins are suitable; match the grain directions. Apparently, pith paintings can still be bought in Hong Kong, which could be an option for obtaining repair material.

f. Display: Pictures that have been cut from their albums in the past should be individually displayed. It is possible to "cradle" each sheet so that there is no application of paste to the pith, nor any restriction of movement by hinges. Cut strips of a suitable material and paste along outer edges to mat backing board so that inner edges of strips overlap pith sheet and hold it securely in place. An eight-ply overlay window mat will ensure adequate protection for the fragile pith surface. This method is not suitable for album display.

E. Tapa

1. General Description

A paper-like fabric or bark cloth made from the inner bark of the paper mulberry (Broussonetia papyrifera) and other plants. Produced and used extensively in the Pacific region as a painting and writing surface, for clothing, wall coverings, etc., since earliest times. Processing includes cutting, soaking, and softening the stalks in water and stripping off the bark. (Tapa differs from paper because the fibers retain their original structure and are not disintegrated.) The inner bark is sun-dried and stored; for processing into tapa it is soaked in water to soften and then repeatedly beaten and folded until it has increased to many times its original width. Large tapas are made by pasting, felting, or sewing pieces together. The many ways of decorating tapa are described in the literature. Tapa continues to be manufactured widely.

2. Inherent Problems

a. Light-sensitive colorants: In particular, modern tapas may feature inks from felt-tipped pens.

b. Water-sensitive colorants, especially "smoked" tapa; water-sensitive adhesive joins between the individual tapa pieces forming the composite object. Joins may separate when wet.

c. Glossy surface coating of coconut oil is susceptible to mold (Green 1987, 59).

d. Storage and display problems for very large pieces. Traditional folding for storage causes deformation and breaking of fibers.

e. Delamination of layers (with age, washing) and usual problems (cracks, holes, tears).

f. Frequently acidic and brittle.

g. Soiling from wear and greasy, sooty dirt accumulated from cooking fires can be a clue of dating (Green 1986, 20).

h. Some may retain rolled or distorted shape of the tree.

3. **Treatment Observations**

a. See Green (1986, 20) for factors to consider; in surface cleaning and washing must not remove ethnographic evidence (soils) for history and use.

b. Cleaning: Vacuuming is acceptable for removal of dust. Take care with paints as they can be friable depending upon binder.

c. Crease removal: Wetting, steaming, and humidification have all been tried with limited success. Tapa must be handled with great care and adequate support when wet because its strength may decrease.

d. Tear repair: Mulberry paper is satisfactory for tears and small voids.

e. Backing/Lining is a treatment of last resort for tapas which are structurally insecure and which would not be adequately supported with patch-type repairs. Linings may obscure previous repairs which may be historically significant. Embossing, if present, should remain visible. In addition, embossing may make it difficult to adhere the backing. Linings also contribute to a loss of flexibility. Lining materials include Japanese paper and contemporary tapa (the latter is preferred, in part because it conforms more readily to the surface irregularities of the tapa primary support). Starch paste or cellulose-derived adhesives are preferred, particulary the latter because in any future analysis it will not be confused with the original adhesive. Nylon laminating tissue and stitching have also been used to adhere linings.

f. Filling voids: See tear repair, above, for treatment of small voids. Larger voids need backing or pulp fills. The latter is the standard treatment and uses coarsely processed pulp.

g. Mounting methods include hinge mounting, pressure-mounting, clips, etc.

F. **Drafting Cloth ("linen")**

1. **General Description**
While "linen" as a primary support was required for all United States government contract work in the 1950s, it was widely used as a support for architectural and engineering drawings

from circa 1850 to 1960 when it was replaced by cheaper, durable polyester films. Drafting cloth was manufactured in Lancashire, England and exported all over the world. The substrate was a linen or cotton fabric and could be bleached, then filled or coated with starch, gelatin or, more recently, synthetic compounds. Sometimes the completed drawing on drafting cloth was coated with lacquer-like coatings, including nitrocellulose, which resulted in a very brittle support.(KN) A glossy coating on one or both sides created a smooth surface that is translucent rather than fully transparent. Drafting cloth is seldom used today because of its high cost and limited availability. Also, it was formerly required for deposit with building inspection departments as a permanent copy, but is no longer (Lathrop 1980, 329).

2. **Inherent Problems**

   a. The textile substrate is very durable and will withstand much abuse. However, a starch or gelatin filler/coating can be destroyed by moisture resulting in distortion, opacity, exposed fibers, and limpness.

   b. The starch or gelatin coating renders drafting cloth susceptible to damage from mold, insects, vermin and foxing.

   c. Heavily filled/coated: Ink and watercolor will not penetrate drafting cloth and, therefore, their application is not permanent. May be washed off with moisture or smeared if handled poorly.

   d. Storage and handling: Rolling, folding, and poor handling techniques crack the coating and will cause it to wear off gradually. Eventually, the cloth will fray around its outer edges.

3. **Treatment Observations**

   a. Mold removal may be successfully accomplished using a vacuum aspirator.

   b. Dry cleaning to remove superficial grime is safe only when the surface is in excellent condition (a smooth, unfractured coating). Eraser particles can become embedded in exposed fibers or "rub out" the fragile coating. Swabbing with ethanol often releases surface grime.(LP)

c. Selected organic solvents have been used with success to reduce staining, adhesive residues, etc. Some linens benefit from cleaning with water and ethanol mixtures.(LP)

d. Mend with heat-set tissue or aqueous adhesives, however, drafting cloth may be heat-sensitive, especially when degraded. Aqueous adhesives will disturb the starch or gelatin filler/coating. Coating can be approximated by applying methyl cellulose and burnishing through polyester film.(LP)

4.4.7 Contemporary Non-Paper Drawing Supports

A. Polyester Drafting Films

1. General Description

Stiff but flexible, colorless plastic sheet with a fine, pebbly surface coating that makes it almost opaque and which readily accepts media. One type, Geofilm (made by Hughes-Owens, Ltd., analyzed at the Canadian Conservation Institute in 1987), was found to have a dimensionally and chemically stable polyester base (unaffected by heat, humidity, solvents) and a coating of quartz (also stable) in a solvent-resistant ester binder (Williams 1987). The binder will probably remain stable if the film is stored in conditions recommended for photographs on a polyester base. Any color change that occurred over the years in such a thin layer of binder would probably be imperceptible. A variety of other synthetic drafting films is available, however, many of which are not as stable as Geofilm. Most have not been chemically analyzed, but spot tests show that some have surface coatings that dissolve readily in many solvents. One such film is Transpagra. The bases of these drafting films may be any of a number of plastics of varying stabilities.

Mylar has also been used as a support for drawings as well as architectural renderings. Jasper Johns drew on Mylar and Andy Warhol has done drawings which contain layers of transparent plastic. Drawings for design items and other industrial products have been done on single sheets and composite pieces of Mylar.(KDB)

2. Inherent Problems

It is difficult to start a tear in polyester drafting films but, once started, the tear extends easily.

3. **Treatment Observations**

a. Conventional mending and hinging adhesives for paper are incompatible with drafting films. Synthetic adhesives, whether solvent or heat activated, must be tested for compatibility with each film, since some films are heat or solvent sensitive.

b. Synthetic hinging materials (Hollytex, Cerex, etc.) have been used with success. These materials, once impregnated with a synthetic adhesive (Lascaux 498-20x, etc.) can be heat or solvent activated. The translucent appearance of the hinges renders them almost invisible.(AM) Double-sided tape has also been used for hinging plastics.(KDB)

c. Large and oversized pieces may have been folded. Humidification is not generally effective. Flattening may be achieved by light application of heat and pressure (conventional tacking iron and silicon release paper) on crest of crease.(SP)

d. Reformatting (e.g., microfilming) should be considered for architectural drawings on unstable plastic although this option is not applicable to fine arts pieces.(LP)

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Participants (listed alphabetically)

Compilers: Thea Burns (Jirat-Wasiutynski) and Karen Potje.

Contributors: Nancy E. Ash, Konstanze Bachmann, Cynthia Ball, Karl D. Buchberg, Robyn Douglas, Katherine G. Eirk, Theresa Fairbanks, Lynn Gilliland, Michele Hamill, Penny Jenkins, Anne Maheux, Jesse Munn, Yoshiyuki Nishio, Susan Page, Lois Olcott Price, Catherine Rickman, Christine Smith, Martha Smith, Rebecca Tombs, Elizabeth C. Wendelin.

Editorial Board Liaison: Antoinette Dwan, Kimberly Schenck.

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