OBSERVATIONS ON THE DRYING BEHAVIOR OF TEXTILES:

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The wet treatment of textiles presents risks which fall into two groups: some are elements of the wet process; others are factors associated with drying. This paper deals with the latter. Textile conservators are familiar with the damages and disfigurement which may result when wetting of a textile is followed by uncontrolled drying. These include staining due to movement of soils, impurities and degradation products; stiffness associated with the stains; dye bleed; and brown line staining of cellulosic fabrics (Hutchins 1983). The risks can be lessened to varying degrees, depending on the amount of control possible over the processes.

Success in controlling drying behavior is possible by working with the natural tendencies of the materials. Many of the variables that affect the drying of textiles relate to capillarity and evaporation. Physical properties of fibers are altered considerably by changes in the amount of moisture present (Morton and Hearle). Since wetting and drying are basically opposites, we can study both processes to understand the natural tendencies. Some of the factors that affect drying behavior follow:

> Fiber Content. A fiber's molecular structure and morphology affect absorption and desorption. Properties such as swelling and shrinkage vary considerably among different fibers. Staple fibers produce very different yarns and fabrics than those made from continuous filament fibers.
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> Fiber Processing. Physical and chemical processing affects fibers in ways that can alter wetting and drying properties. For example, mercerization changes the morphology of cotton. Moisture regain is one property affected: normal cotton has a regain of 8.50% while mercerized cotton has a regain of 10.50% (Identification of Textile Materials, 1975). Mercerization also results in a difference in the cross sectional swelling in water-- the cross sectional swelling of cotton is 21% and that of mercerized cotton is 24% (Harris 1954).
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> Many other aspects of textile processing affect wetting and drying behavior. Among the questions that should be asked are:
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> Is the warp yarn sized or unsized?
> Has the fiber been oiled to facilitate spinning?
> Is the wool greasy, scoured, or somewhere in between?

Fiber Diameter; Yarn Size; Amount of Yarn Twist. These three factors, which combine fiber morphology with fiber and yarn processing, will in part determine the number and the size of pores within yarns. The smaller the pores, the greater the capillary force. Differences in fiber diameter, yarn size, and pore size, contribute to differences in the way water moves into and out of each structural element in the fabric (Michalski, 1981 and 1984).

Fabric Structure; Compactness of Weave. The fabric might be woven, knitted, felted, or constructed by another method. A weave may be balanced or unbalanced, warp predominant, or weft faced. Fabric structure and compactness of the weave help determine another level (another size) of capillary spaces in the fabric (Michalski, 1981 and 1984). An elongated stain shape may be due in part to fabric structure, although fiber content, yarn construction, and physical factors also have an effect. Some fabrics show a marked difference in the ability of the warp and weft to move liquids by capillary action. The compactness of the weave will also affect the amount of yarn surface exposed and may affect the length of time a textile takes to dry.

Fabric Finish will affect wetting and drying behavior, especially when it acts as a coating on the fabric surface. The coating may be either a hydrophilic or hydrophobic substance.

Fabric Use adds influences that help determine wetting and drying behavior and may cause the textile to behave differently in various areas. Factors in the category of fabric use include wear, previous wetting, the nature and amount of soils present, and detergent residue.

Physical factors at the time and location of drying also affect drying behavior. The amount of water present in the textile when drying begins is one example. A tapestry could be left close to waterlogged; it could be drained, blotted, rolled with toweling; other treatment steps could be taken to remove liquid water as a preliminary step in drying. Other physical factors include the temperature and relative humidity in the environment, air movement, and use of supplementary materials or equipment such as blotters, drying cloths, or suction tables. It is important to note that these physical factors, unlike the nature of the materials, can be altered in an effort to control drying and the effects of drying.

The nature of the materials combines with the physical factors to determine another critical matter, that is, the length of time a textile takes to dry. In discussing drying with conservators, most mention the importance of drying the textile as quickly as possible. This principle doesn't necessarily inspire conservators to greatly accelerate drying by using methods such as heated air, (although this is sometimes used), but it does result in use of techniques to remove liquid water from the surface and interstices of the fabric by such techniques as sponge-extraction and repeated blotting.

SPECIFIC CASES

In specific cases it is a combination of factors that will determine the actual drying behavior. But different factors will not play equal parts; one factor can be much more influential than another. The following examples of drying treatments present particular textiles and drying problems, and describe how physical factors were manipulated in order to influence the drying process and outcome.

1. CONTROLLING BROWN LINE STAINING

Textiles vary in their dimensionality, and the topography of the textile has a very significant effect on drying behavior. In cases where the fabric is relatively small, thin and flat, we usually observe that the edges dry first and later the area of drying moves toward the center. More often we are working with textiles that have great differences in thickness and weave density, multiple layers, and distortions. Then drying begins at many different locations including the edges, thin areas, and areas around tears and holes. Moisture moves from areas of greater water content toward drier ones. Consideration should be given to wicks inherent in the fabric. These include:

1. Pile, as in a candlewick bed cover
2. Fringes, which are often stained from past uncontrolled drying
3. Ravelling at damaged edges or around holes.

Research described by Jane Hutchins in her report on water-stained cellulosics (Hutchins, 1983) describes the formation of a type of brown staining. This staining has been observed to form during drying, even on clean, carefully prepared, uncontaminated, cellulose fabrics. Hutchins reports that the brown staining is (at least at first) soluble and the boundary of the stain is acidic and degraded. In historic textiles other brown staining occurs due to movement and redeposition of soluble soils and degradation products.

Textile conservators have no difficulty understanding the problems consumers have experienced with cleaning so-called "Haitian Cotton" fabrics. Old quilts often have cotton batting that has not been fully cleaned of cotton trash. Bits of cotton boll, leaf, and twigs -- that show up as brown flecks -- do bleed brown color and can stain the fabric during drying.

Both types of brown staining -- the type produced even by perfectly clean cellulose, and that formed by redeposition of impurities--can be prevented from forming on the textile by use of what can be called a "drying cloth". The technique has been used by textile conservators for a long time. Different materials and variations are used but the principle is this: After washing, a cotton cloth is placed in direct contact with the textile (drying cloth usually on top) and is left in place until the textile is dry. Brown staining, if it forms, will form on the drying cloth, which is removed after drying. Some conservators have observed that the formation of brown staining on cellulosics occurs more often or is more severe, when a textile is left with too much water, or when it takes longer to dry. Conservators working in spaces without climate control are attentive to ambient conditions and may choose to use a dehumidifier or to cancel wet cleaning altogether when relative humidity is high and would slow drying.

One quilted bed cover treated at the Textile Conservation Center had been extremely damaged due to past uncontrolled drying. Dark brown tide lines near the edges indicated the direction of drying (toward the edges). Also notable was brown staining present on the fabric at high points between rows of quilting stitches. The staining proved to be water soluble and wet cleaning was performed. After wet cleaning the quilt was positioned for drying and a drying cloth (in this case a cotton sheet) was placed on top, in direct contact with the quilt. After drying, although a significant amount of staining was left on the drying cloth, there was no brown staining on the quilt.

When using a drying cloth two points are essential: there must be very close contact with the textile, and, the cloth should stay in place until the textile is dry.

2. CONTROLLING DYE BLEED IN SURFACE EMBROIDERY

Sometimes one factor will take priority in determining the drying technique. This was the case with the treatment of an Indian embroidered textile, which illustrates two points: controlling the direction of drying and use of a drying cloth to control dye bleed.

The Indian textile, a plain weave cotton fabric with silk embroidery, was soaked by a leaking roof that went unnoticed for some time. When it was discovered, the textile had flourishing mildew, stiffened stains, and matted surface embroidery. Purple and black dyes were particularly sensitive and had bled into surrounding areas. Due to the severe disfigurement and positive response to cleaning tests, the treatment was to include immersion wet cleaning.

For the drying segment of treatment there were some competing factors to consider. Ordinarily, in order to facilitate the drying, the piece might be positioned up on screens. Also, in order to avoid brown line staining of the cotton ground fabric, it should be dried in contact with a drying cloth. Third, the problem of the bleeding dye needed to be addressed.

The textile's structure was the deciding factor in choosing the drying process: The structure was a type of surface embroidery, which employed a stitch that nearly covered the front surface, but wasted no silk on the rear. Because the embroidery itself was water-sensitive there was risk of dye spreading sideways into adjacent embroidery or into the absorbent cotton ground fabric. It was desirable to control the drying in an upward direction--toward the embroidery. The textile was positioned face up for drying, with the ground fabric in direct contact with the stainless steel wash tank. With a non-absorbent material and little air on the underside, it was predicted that the top would dry first; water would wick upward toward the drier front surface with the embroidery.

A drying cloth was placed on the top surface and a low speed fan was used to accelerate the drying. During drying it was observed that although dye was bleeding, there was very close contact between the textile's embroidered surface and the drying cloth. Dye was taken up by the drying cloth but was not spreading away from the sources of staining. For instance, the triangular-shaped embroidered designs, where purple color was fugitive, produced directly matching, clearly defined, triangular-shaped stains on the drying cloth. After drying, the dye stained sheet was removed. The appearance of the textile was significantly improved and bleeding dye had not stained adjacent areas.

It is worth mentioning the use of suction tables in addressing the concern for control of bleeding dye. In a suction table treatment the textile discussed here would likely be placed front down. The air pressure would maintain the necessary contact between the textile and the blotter underneath, thereby helping to control the capillary action and the bleeding dye.

3. CONTROLLING DYE BLEED IN HOOKED RUG PILE

One last conservation treatment demonstrates an opportunity to use the textile structure and capillary action to control bleeding dye during drying. A hooked rug, treated at the Textile Conservation Center in 1991, was constructed of a bast fiber ground canvas with multi-colored cotton fabric strips forming the pile. It had been wetted previously and dyes had bled on both the front and rear. The dyes were still water-sensitive which was both an asset and a risk. The treatment included a method to control the dye bleed during drying by using an adaption of a drying cloth.

The treatment was designed to take advantage of several aspects of textile drying behavior. First, water, and anything carried with it, moves from wetter areas to drier ones. Second, a thin edge of fabric exposed to the air will dry fast and will dry first. Some of the primary drying sites are found at high points on the textile surface.

In treatment of the hooked rug, thin fabric edges were purposely created around areas of bleeding dye. This was done by taking strips of fine cotton fabric and stitching them between rows of hooking. (Please note that object condition determines whether this treatment is possible.) As stitches were taken along the center of a fabric strip and through the rug, a fold in the fabric strip was pulled down between rows of hooked pile. The "drying cloth" fabric strips extended approximately one inch above the surface of the rug. Areas tested for drying behavior indicated that the fabric strips worked effectively as wicks; liquid was drawn up into the strips, thereby preventing staining of the rug itself. Strips of the sheeting were stitched around all problem dye areas.

With the fabric "wicks" in place the rug was wet cleaned. Afterward it was blotted repeatedly on both sides to remove as much water as possible. It was raised up on screening and a fan was used to hasten the drying. During drying it was observed that dye moved from the hooked pile fabrics up into the strips of cotton sheet and was deposited there. After drying, the strips of cotton fabric, significantly stained with dye (especially at the uppermost edges), were removed from the rug. The rug was not stained.

In summary, these examples show that the interaction of the materials and physical factors produces certain treatment results. Alteration of the drying conditions for textile treatments can significantly influence the drying process. Further testing and experimentation with new materials will undoubtedly lead to even greater control of treatment processes and outcome.

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THE EFFECTS OF WET-CLEANING ON DRY-SITE ARCHAEOLOGICAL TEXTILES: RESULTS OF A PILOT STUDY

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I. Introduction

Textiles seldom are recovered from archaeological sites except when they have been buried in anaerobic conditions, or in conditions of extremely low ambient relative humidity. Conditions of low relative humidity have been responsible for the preservation of significant quantities of fabric in Peru; the condition of these textiles varying according to burial conditions as well as prior influences of processing and manufacture, and later influences of excavation processing, conservation treatment, handling and storage.

The range of condition varies from both cotton and camelid examples that are powdery and have little remaining structural or physical integrity, to examples that are sturdy and supple. However, while no systematic study of moisture content has been undertaken, it can be observed that on the average, these textiles tend to be drier and more brittle than historic textiles of comparable age.

The current condition of Peruvian archaeological textiles in the Museum's collection is as variable as the techniques used over the past 70 years to clean them. In removing many of these textiles from old mounts, both for space economy and to remove non-archival support materials such as pegboard, questions have arisen as to the impact of some of the early treatments on the condition of the textiles as we see them today. To begin to answer these questions, a pilot project was devised to look at wet-cleaning and evaluate the impact of this treatment on dry-site archaeological textiles.

II. Experimental Procedure

A. Fabric Selection

Two diverse groups of archaeological textiles, both from Peru and both still in their field dirt, formed the basis of this research. The first group, mostly cellulosic, was collected in the 1940's from a looted cemetery in Cao Viejo on the North Coast. The second group, mostly camelid fibers, was collected in the 1960's from a series of caves in Huanaca Sancos in the southern Highlands.

As each collection contained textiles exhibiting a variety of techniques in weaving, dyeing, and surface embellishment, the choice of samples was based on simplicity, i.e., the fewest number of variables to account for. The cottons chosen were all plain weave, although some contained the Chimu characteristic of paired warps. The camelid textiles chosen also were plain weave, but only