

A SYSTEMATIC APPROACH FOR THE COMPARISON
OF PAPER SAMPLES

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I Introduction

The examination of paper as physical evidence has traditionally been the duty of the document analyst. Document examiners routinely have examined the physical characteristics of paper such as size, weight, thickness, opacity and fluorescent properties; however, few have delved into the analysis of the actual structure of paper. This requires highly specialized training in areas normally outside the realm of work routinely performed by a document analyst.

In crimes of fraud, paper evidence can have high evidentiary value. For example, paper analysis may detect numerous types of counterfeit documents such as currency, food stamps, stock certificates, wills and various types of identification documents such as driver licenses or social security cards. In other situations the date of preparation of a document may be in question, and an exhaustive analysis of the paper may lead to a conclusion that the alleged date of preparation is not possible.

Paper evidence is normally thought to consist primarily of documents. Although documents are more abundant and generally

more significant, other types of paper evidence are also encountered such as pieces of cardboard found at a bomb scene, blotter paper at a clandestine drug operation or constituents of so-called water soluble paper found in a can of water at the site of a gambling operation.

This paper describes several methods used in a systematic approach for the examination and comparison of paper evidence, as well as the value and limitations of paper as evidence.

II Methods of Examination

A) Physical Characteristics

The first examinations conducted on paper determine the physical and visual properties of the paper. These examinations include noting the color and measuring the size, weight, opacity and fluorescent properties of the paper. This level of examination is rapid, non-destructive and often sufficient to prove two or more samples of paper are different.

B) Watermark Examination

An important physical characteristic of many papers is a watermark. Watermarks are imprinted or pressed into the still-wet fiber sheet during the manufacturing process. This is accomplished by passing the wet mat of fibers across a dandy roll, which is a metal wire cylinder containing patches of

specific pattern designs. The design patches are generally of two types - wire or screen. Both types are made in various ways and provide a variety of appearances of which lines and shaded watermarks are the most common. (See Figures 1 and 2)

Watermarks can also be placed on a sheet of dried paper either by mechanical or chemical means. Mechanical marks are formed by the use of molds or presses and these watermarks are readily detectable by their embossed appearance. These designs usually have a local origin as opposed to being nationally or regionally distributed. Chemical watermarks have been used for many years and have been widely distributed in the form of Customarks^R by Fox River Paper Company of Appleton, Wisconsin. These watermarks appear similar to conventional watermarks, but can be distinguished by examination under ultraviolet light, or by soft x-ray examinations. A chemical watermark will appear darker than the rest of the paper whereas a conventional watermark, when viewed under ultraviolet light, will appear lighter than the remaining paper background. Chemical methods are also available for differentiating between chemical and conventional watermarks. (1)

Through files maintained by the ATF Laboratory and reference texts (2 and 3), the origin of a watermark usually can be determined. Other valuable information often obtainable from watermarks is the date of production. The most direct means of accomplishing this is to note the presence of a coded watermark which reveals the first possible date of production of the paper. If the watermark is not coded an attempt is made to record the history of changes which have occurred in the design of the watermark. Dates provided by the manufacturers regarding coded watermarks or changes in designs can provide valuable information to determine the earliest date of production of a questioned document. This is often helpful in showing discrepancies between the first date of production of a specific paper product and the alleged date of preparation of a questioned document.

C) Fiber Analysis

In situations where examination referred to in A and B indicate similarity it is possible to proceed further to determine whether the papers in question have the same fiber composition. It is quite possible for papers to have the same watermarks and physical characteristics and still have entirely different fiber and chemical compositions.

The well trained examiner using established procedures (1, 4 and 5) can identify the types of fibers (cotton, wool, etc.)

used in the paper as well as determine the pulping processes used. The percentage of each type of fiber can be determined whenever mixtures are present, as well as the different species of wood fibers. This information is found primarily through microscopic examination utilizing fiber staining techniques and observing the morphological characteristics of the fibers. (Figures 3 and 4 illustrate this.)

Fiber analysis is sufficient to distinguish many types of papers and similarities at this level of examination may very well indicate common origin. Conclusions as to common origin cannot be stated conclusively, however, because the chemical components of the paper must still be considered.

D) Chemical Analysis

After conducting examinations described in A, B and C only the analysis of the chemical and trace elemental components of the paper remains. Paper products contain a large variety of chemical ingredients such as sizing and loading materials, fillers, whiteners, plasticizers and waxes. Examples of such components are starch, glue, clay, calcium carbonate, titanium oxide, talc and paraffin wax (1, 4, and 5). These components can be present in a large number of different combinations and provide useful characterizing information. The results of

these examinations can serve to prove similarity or dissimilarity of paper samples and can also serve to determine the earliest date of production of a paper sample, providing the paper manufacturer has been identified and has maintained accurate records of the changes in his product.

Figure 5 shows how the systematic examination of a paper sample, along with manufacturer cooperation, can lead to a distinct time period in which the product was produced. In this case the changes were quite extensive involving the various constituents of the coating. Figure 6 also illustrates how the manufacturers' record of a change in his product allowed for the approximation of the time of production of a paper sample. Fluorescence, in this case, was the key factor in ascertaining the time of production of the questioned paper sample.

The above sequence of examinations provides numerous points for comparison of questioned and known samples of paper. If the results of these examination are in agreement there is a high degree of scientific certainty that the questioned and known paper samples are the same and have a common origin.

E) Trace Elemental Analysis

When it is considered necessary to further establish the similarity of paper samples or to try and determine the

approximate time of production of the paper, trace elemental analysis is performed. Reported methods for determining the trace elemental compositions of papers are primarily neutron activation analysis and x-ray fluorescence, with recent work being done by scanning electron microscope (SEM) and emission spectography. (6, 7, 8, and 9)

Measurement of the trace elemental compositions of papers provides highly individualizing information in that the trace elements are contributed to papers by the processing equipment used and through the impurities in the numerous additives of paper. Studies have verified that there is statistically very little chance that any two manufacturers will produce a paper product containing the same trace elements present in the same relative concentrations (explained in reference 7). As a result, when two or more samples have the same trace elemental compositions and examinations performed in A, B, C, and D indicate similarity it is possible to conclude with a high degree of certainty the papers have the same origin.

This level of examination can assist in the determination of the approximate period of time a paper sample was produced. This is accomplished by comparing the results of a questioned sample with known samples which have known production dates several years before and after the date of the questioned document. The known samples are obtained from the manufacturer

thus necessitating manufacturer identification prior to this examination.

Differences found when comparing papers at any level of examination serve to indicate that the papers being compared are not the same; however, when the results of examinations A, B, C, D and E fail to reveal any significant differences, it is then possible to conclude that the questioned and known samples came from the same source or from some other source which may possibly give the same results. The possibility of some other source of paper providing the same result, however, can be considered extremely remote.

III Summary

A systematic approach to the examination of paper evidence has been described which consists of several levels of examination. This examination primarily includes: 1) the measurement of physical characteristics, 2) watermark examination, 3) microscopic fiber analysis, 4) chemical analysis and 5) trace elemental analysis. These procedures provide numerous points of comparison which can serve at any point in the examination to prove that paper samples are different.

While it is not possible to conclude with absolute certainty that paper samples have the same origin, the examinations we

have described can serve to provide valuable corroborative evidence pertaining to whether or not paper samples have a common origin. The procedure can also assist to disprove or verify the alleged preparation date of questioned documents.

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