FRACTAL ANALYSIS AS INVESTIGATION METHOD IN OLD ORGANIC SUPPORT

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Abstract. The investigation of the material's properties of the patrimony objects is necessary to understand both the reaction of the objects to the environment in order to create the optimal conditions to preserve them and to act on the objects in order to decrease the degradation. Fractal geometry offers a new approach to describing the structure of different irregular objects, fractal design principles occurring in a very large number of phenomena. In order to identify the specific properties of some kind of materials (leather, paper, linen), from organic book cover, the fractal analysis was used in this work.

Key words: fractal dimension, HarFA soft, organic book cover.

INTRODUCTION

Patrimony objects represent the material proofs of evolution of the life's mode, intelligence and sensibility of humanity. Now more than in the past, the researchers use the advanced technologies in order to study and preserve the patrimony objects. The investigation of the material's properties of the patrimony objects is necessary to understand both the reaction of the objects to the environment in order to create the optimal condition to preserve them and to act on the objects in order to decrease the degradation. The scientific research of some kind of materials (leather, paper, linen) is very important not only for preservation of the patrimony objects, but also to obtain informations about their age. For example, in the case of the textile objects, the characteristics of texture, the manufacture, colorants used and so on, can be good elements in order to establish the age, the provenience and, in addition, their authenticity. From the structural point of view, the basic structure of leather is a matrix that consists of collagenic fiber bundless, interlaced under different angles. The collagen is a proteic biopolymer

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submissived in time to a different process of damage under biological, physical, mechanical and chemical factors. The textile materials from the objects of art are composed especially by natural fibers (proteic or cellulosic) that are also damaged from the same type of factors. Textile and leather are hygroscopic materials absorbing water from atmosphere that encourages the biological degradation.

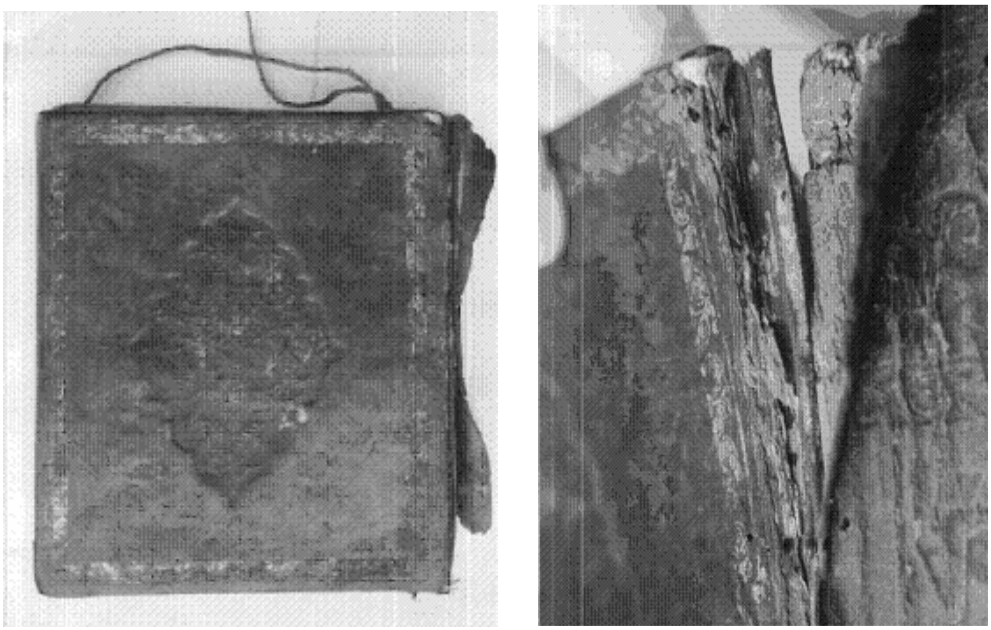
The scientific investigation of old leather and textile objects makes appeal to physical techniques in order to establish a reliable treatment scheme. These techniques give valuable data on the material type, preservation state, processing method, previous interventions, etc. The electron-microscopy is a technique enabled to make studies on leather and textile morphology. Among all microscopic methods, the electron-microscopy gives the best image resolution and the most accurate information on crystallinity, morphology of different structural types and surface structural topography [10].

Fractal geometry offers a new approach to describing the structure of different irregular objects, fractal design principles occurring in a very large number of phenomena from physics, chemistry, cosmology, biological structures, art and so on [1, 2, 5–8, 11–13]. Benoit Mandelbrot [9] conceived of fractals (from the Latin *fractus* = irregular) as a set of forms constructed by iteration and that are characterized by infinite detail, infinite length, no slope or derivative, fractional dimension and self similarity. The fractals theory has been increasingly applied in the field of materials science. Models of fractal lines and surfaces have been generated to describe the microstructural features of materials. In this area fractals can be used to help analyze surfaces that were formed through some physical processes. It should be noted that surfaces can change their morphological characteristics by exposure to external influences or environments. Characteristics of crystalline structure, roughness and nanotribology of ZnO thin films deposited under various power conditions were studied by means of X-ray diffraction, scanning probe microscopy and fractal analysis [14]. The behavior of fractal crystallization in a Pd/Ge thin film system has been investigated by transmission electron microscope and fractal analysis [15]. Fractal Analysis is a method also used to study surface properties of biomaterials [3]. Feder [4] suggested that the fractal dimension is proportional to porosity. The materials with a higher fractal dimension are less porous than those with a lower fractal dimension, and consequently there is a direct relationship between the amounts of water withheld by a material and its fractal dimension. In this paper the fractal analysis is used to determine how the environmental conditions influence the preservation of patrimony books.

MATERIALS AND METHODS

Samples from leather, linen and other textile were preserved from actual and old book covers. The old book used, named *Evhloghion*, having a leather cover and a linen back cover is from the XIX century (Fig. 1).

The samples were scanned with Scanning Electron Microscope Tesla BS-800.



a. b.

Fig 1. The old book *Evhloghion* 1834: a. book cover b. back cover.

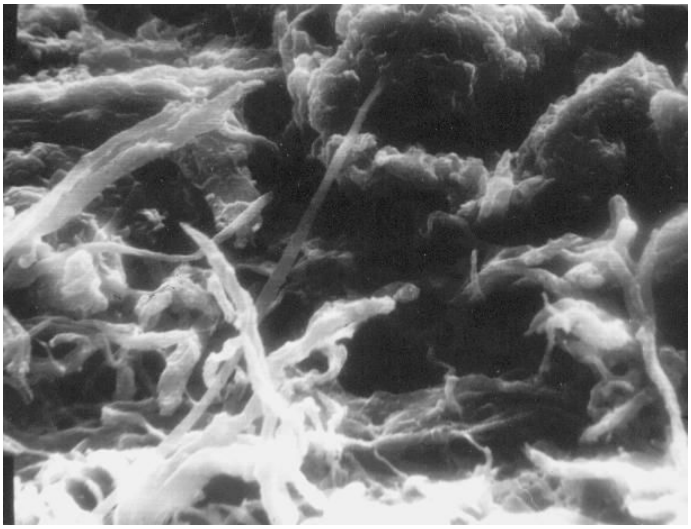


Fig. 2. Sample from actual leather book cover (×1800).

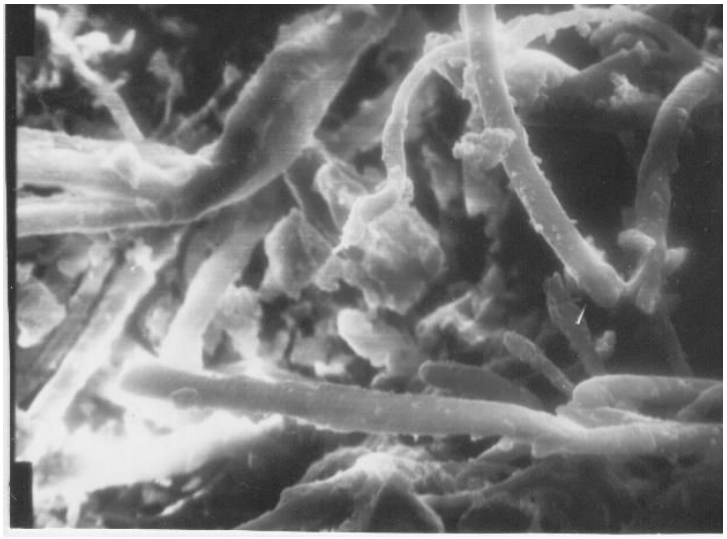


Fig. 3. Sample from old leather cover book (×1800).

We used the same method for actual and old linen.

Fig.4. Sample from actual linen (×3000).

Fig.5. Sample from 100 years old linen (×3000).

RESULTS AND DISCUSSIONS

In order to identify the specific properties, which differentiate the actual sample by the old ones, the fractal analysis based on Box Counting Method was used. Box-Counting Method determines the fractal dimension of black&white digitized images of fractals. It works by covering fractal with boxes and then evaluating how many boxes are needed to cover the fractal completely. Repeating this measurement with different sizes of boxes will result into logarithmical function of box size and number of boxes needed to cover fractal. The slope of this function is referred as box dimension which is taken as an appropriate approximation of fractal dimension. HarFA specialized soft modified the Box Counting Method. By this modification HarFA determines, not one, but three fractal dimensions DB, DBW, DW, which characterize properties of black plane DB, black-white border of black object DBW and properties of white background DW. The most important fractal dimension is DBW dimension, which is the slope of the straight line Black & White.

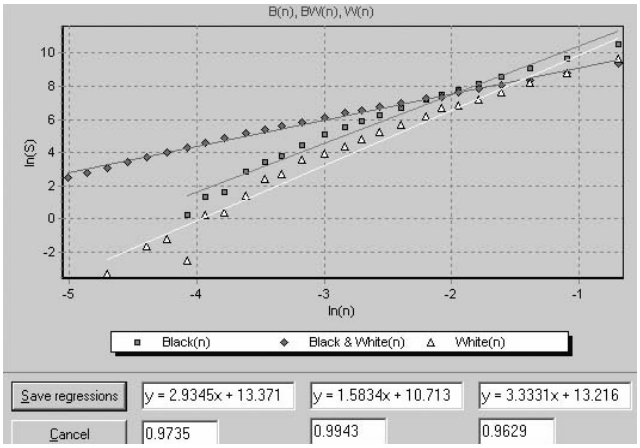


Fig. 6. Fractal dimension for the sample from actual leather book cover.

Our measurements showed that the fractal dimension is 1.5834 for actual leather book cover and 1.5853 for old leather book cover, this means closed values. For actual leather book cover DW is higher than DB, for old leather book cover DW decreases while DB increases in the same way. By contrary we obtained for fractal dimension 1.6694 for actual linen book cover and 1.6829 for 100 years old linen book cover; this means an increased fractal dimension for old linen. For actual linen DB and DW are equal approximately but for old linen DW increases, this means that in old linen halls appear because of the damage process. On the contrary, the leather is damaged by decreasing of halls between fibers.

CONCLUSIONS

In this work we pointed out the importance of the concept of fractal structure in physical characterization of materials. The fractal dimension is closely related to roughness of the fracture surface and to mechanical properties such as fracture toughness. The fractal dimension is higher for old material book cover than the actual material cover book. It varies moreover for linen book cover than for leather book cover. In time, the damage of leather is less than of the linen; this means the leather book covers are better than the linen book covers. The fractal analysis can contribute to a better understanding how the environmental conditions influence the preservation of patrimony books. New methods of investigation and a new method to determine the fractal dimension for book covers are necessary in the future in order to understand how the porosity of these organic materials is connected to the fractal dimension.

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