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An Interim Treatment for Paper Degraded by Verdigris

INTRODUCTION

The Library of Congress's "Theatrum Orbis Terrarum", published by Abraham Ortelius in 1570, is impaired by considerable verdigris degradation to the paper. The book is important because it is the first bound uniformly sized, systematically organized collection of maps depicting the countries of the world. It is known as the first modern atlas. Ortelius created the atlas as a reference work which was to become the prototype of almost all geographical atlases from 1570 to modern times.

The atlas in its original full leather binding in calf skin with the herald device of John Bishop of Münster, Osnabruck and Paderborn is lavishly gold tooled with highlights painted in red, white, and brown pigments (fig. 1). The page edges have also been gilded in gold. The spine has been extensively damaged and poorly repaired. The book is very rare as it is the first printing of four editions to appear in 1570 and is made more valuable by its original binding dated 1570 on the front cover.

ABRAHAM ORTELIUS (1527-1598)

Ortelius was tall, slender bachelor with balding hair and gray eyes, as we read in his obituary printed in the 1607 English edition of the "Theatrum Orbis Terrarum" (fig. 2). Ortelius was greatest expert of his day in bibliography of maps. This expertise was derived from studying historic maps and a corresponding widely with geographers, foreign scholars, merchants and sailing captains. Much of this correspondence was concerned with receiving new maps and correcting old maps. In the 16th century new territories and lands were frequently being discovered and explored each year. There are still 376 letters of his correspondence preserved in the collections of Jacob Cool Jr., Detroit, U.S.A. and in various libraries around the world. In other words, the "Theatrum Orbis Terrarum" was a co-operative enterprise on a international basis.

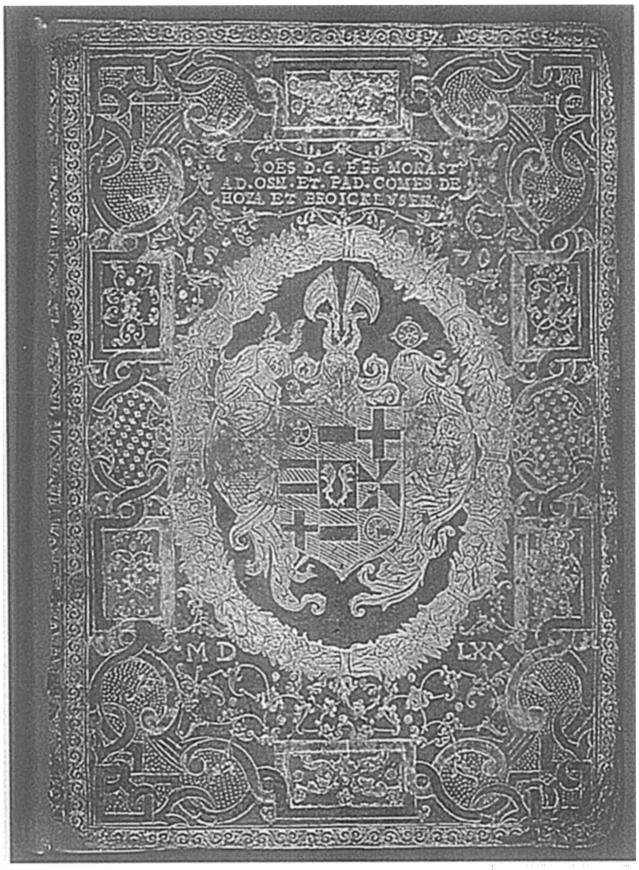

Fig. 1. Cover of "Theatrum Orbis Terrarum" published in 1570 by Abraham Ortelius

As a publisher, Ortelius had close intensive contact with printers, engravers, authors, colorists, publishers, and artists. Among his colleagues in Antwerp was the painter Jan Bruegel. Bruegel was almost the exact same age as Ortelius and belonged to the artist guild of St. Luke. Bruegel painted for him the small grisaille "The Death of the Virgin"; which Ortelius had engraved by Philip Galle and published with Latin verses. Ortelius held Bruegel in

Fig. 2. Portrait of Abraham Ortelius at the age of 50 engraved by Philip Galle and included in the editions of the "Theatrum" of 1579 and later

high regard, writing his epitaph when the painter died prematurely at the age of 40 in 1569.

Antwerp, in the first half of 16th century was a grand city and the hub of the first truly global economy stretching from the East Indies to Peru; an international port packed with shipping. For an intoxicating few decades Antwerp was the center of European civilization. This was the golden era of Dutch cartography; with Antwerp printing presses turning out almanacs, anatomies, breviaries, herbals, history, broadsides, artist productions and maps. These maps reached a world-wide market. For example, in the year 1570 four, slightly differing, editions were printed of the "Theatrum Orbis Terrarum" . As the popularity of the atlas grew it was quickly translated into six languages, becoming a best seller of its day. The atlases were used by merchants, sailing ship captains, as well civil, ecclesiastical and military authorities. They also served a decorative function as the status "coffee table book" of its day.

PRODUCTION AND CONDITION OF THE THEATRUM ORBIS TERRARUM

Ortelius's selection and compilation of maps for his atlas required several years. First, he had to find the most up-to-date and reliable maps of his time and get permission of cartographers for use of their maps. In some cases the information was previously unknown or drawn from travel diaries as in the case of interior portions of Asia, Africa, and the Americas. On the other hand, some maps were extraordinary clear and accurate such as Mercator's map of Flandia, one of the most important maps in the book (fig. 3). The Flandia map is remarkable even today, as there is less than 3.4% deviation from actual distances between towns. Mercator, the foremost cartographer of Europe, published the map of his home

Fig. 3. Map of Flandia by Gerhardus Mercator published in 1540

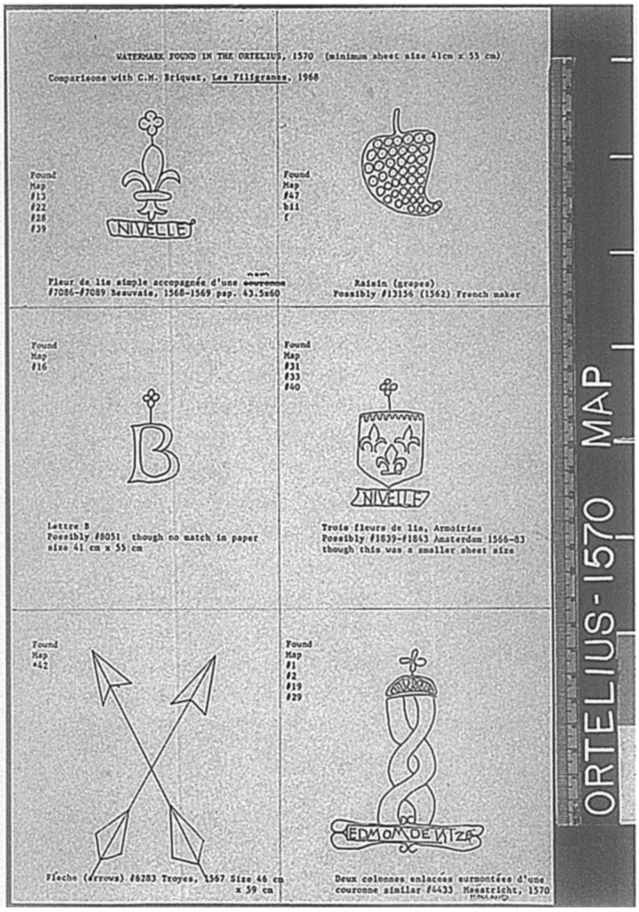

Fig. 4. Sketch of six watermarks found on the maps and text paper

territory in 1540 and allowed Ortelius to use it. The accuracy of the map is in part due to the slow, scientific methodical work of Mercator. Ortelius, on the other hand, was primarily a map seller and publisher.

The "Theatrum Orbis Terrarum" is printed on antique laid paper made from linen/rag pulp using at least six different molds from evidence of the watermarks which include; fleur de lis, fleur de lis on a shield, grapes, the capital letter B with flower, crossed arrows, and intertwined columns with the name d'Edmond Denise (fig. 4). This range in papers may help explain how verdigris has extensively degraded some papers while others are in fair condition. The average map and text paper in book was between 6-6.5 pH before treatment. The paper is in very poor condition due to the presence of verdigris. Besides damage related to verdigris there are problems associated with old repairs made to the embrittled paper. These often poor repairs have resulted in distortions from using inappropriate repair papers and techniques (fig. 5). There are, as well, the typical problems one would expect to see in such an old book, distortion of text paper from binding, general cockling of paper, stains, foxing, dirt, grime, and small edge tears.

The engraving of the 53 maps on copper plates required two years and was carried out by Francis Hogenberg and his assistants. The engraver was responsible for many of the fine cartographic details including the cartouches which often included animals, plants, strap work, cherubs, ribbons, sailing ships, and heraldic devices. A good example of the engravers' art is the map of Salzberg where a rolled border edge appears with heraldic devices, compass rose, and a view of the city (fig. 6). After the plates were engraved the book was printed by Aegidius Coppen Diesth on a letter press with subsequent editions printed by Platijn.

The coloring of maps in the atlas served a double purpose, making them beautiful and differentiating adjacent areas, political boundaries, and geographical features. Colorists were not restricted; each edition was colored quite differently as were individual maps from book to book in an edition. We can see this from examining copies of the same edition as well as later editions at the Library of Congress. On map number 53 we see the watercolorist has applied green color to the upper and lower areas. In the lower green area the paper is severely degraded while the upper green appears stable. This indicates that colorists

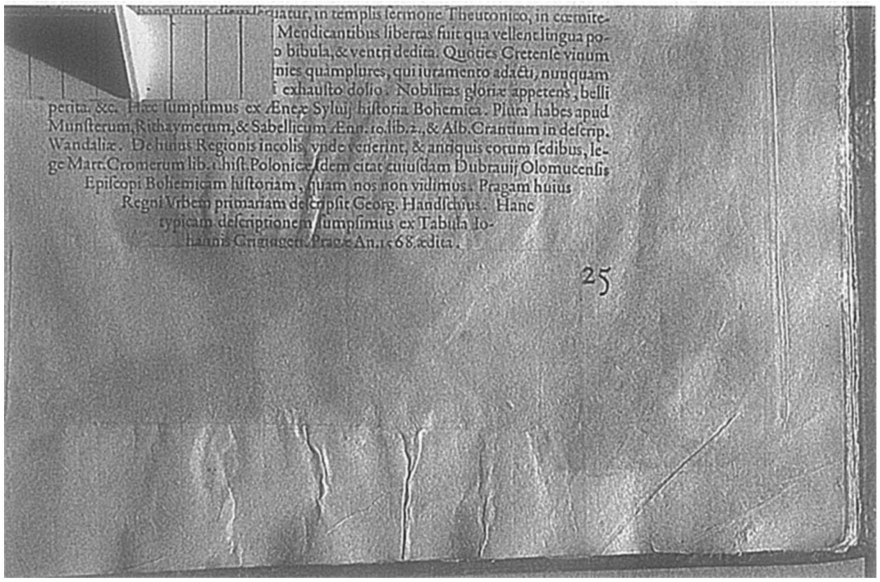

Fig. 5. Distortions and stains caused by old repairs

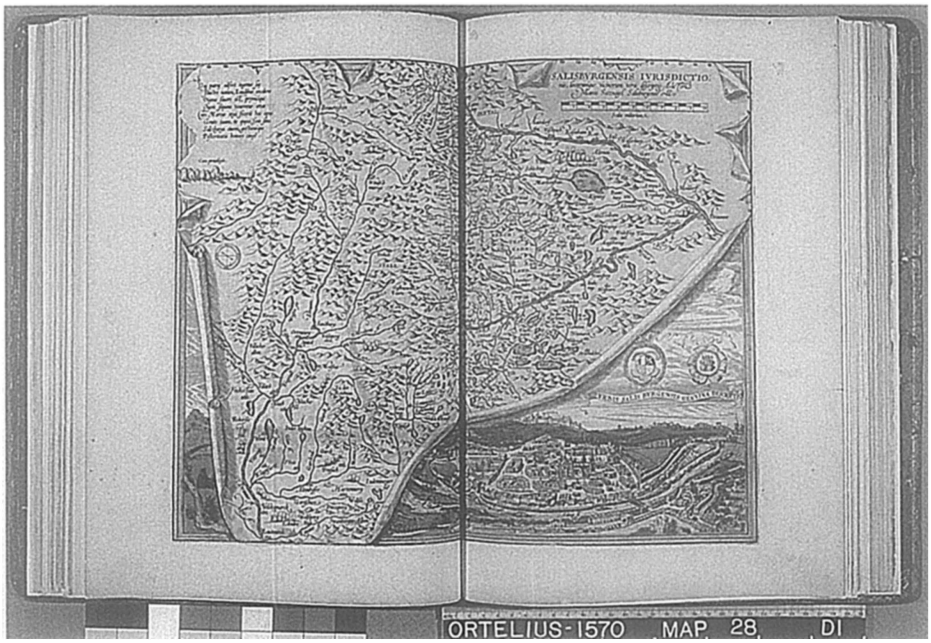

Fig. 6. Map of Salzberg based on an original of 1551 by Marcus Secsnagel who in a poem (top left) expresses the hope of being perpetually remembered

had stable green colors available and intentionally used the green verdigris despite its bad reputation (fig. 7).

VERDIGRIS

Verdigris was made and used as a colorant on a large scale and used in the decorating, dying industry. It was both cheap and easy to obtain from a druggist in the 16th -18th century.The problem of paper degraded by verdigris is common in libraries and art collections all over the world and has not been solved yet. The degradation as seen in the atlas follows a progression including: 1) The color shift from emerald green to olive green, to sepia and brown; 2) The pigment sinks into the paper, sometimes in uneven concentration of the pigment, splash or droplet of water color; 3) The degradation products stain the reverse and off-set to adjoining pages. 4) The embrittled paper becomes brown and extremely fragile, folding or handling causes paper to crack with fragments detaching and falling out. An example of extremely embrittled paper is the Flandia map where a network of small losses, cracks, and tears are visible in transmitted light (figs. 8, 9, & 10).

The production of green colored pigments from the corrosion products of copper, brass, and bronze has been known since ancient times. Verdigris means "green of Greece", (vert de Grece) and is the oldest of manufactured greens. Crude verdigris, sometime called basic verdigris, is produced by exposing copper to vapors of vinegar, sour wine, or other weak acids. The crude verdigris is produced by the action of the acetic vapors on strips of metallic copper producing a blue, green, verdigris a combination of copper carbonates, copper chlorides, copper ions, copper sulfates and other compounds depending on the reactive components present. Refined verdigris or neutral acetate is the product of recrystalization of the basic copper acetate mixture in acetic acid. The copper acetate appears as a blue-green colored crystal (fig. 11). Neutral verdigris has been available as a colorant since ancient times however several times more expensive than the crude verdigris. Most artists in the past considered the neutral form of copper acetate as not worth the extra expense.

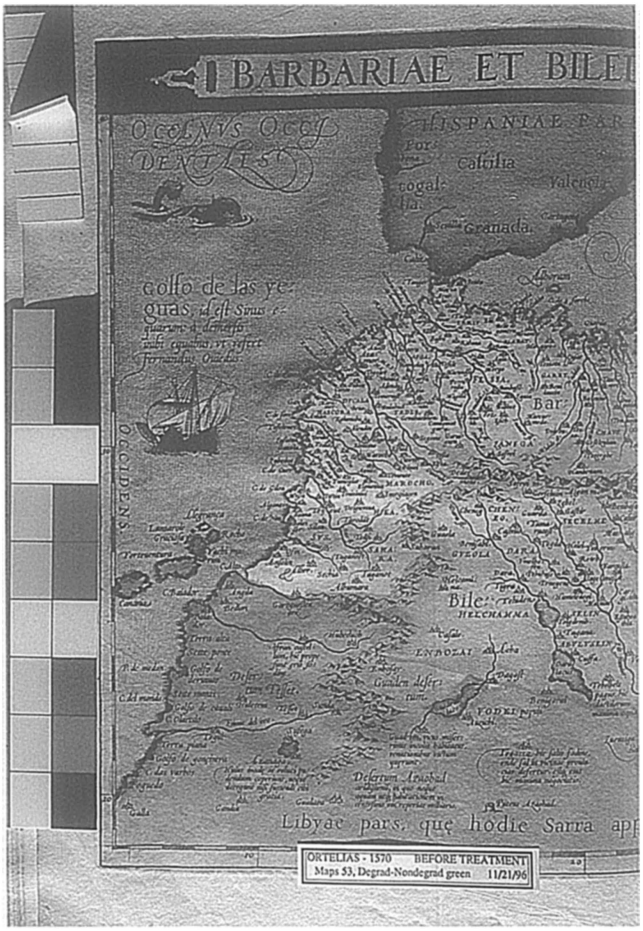

Fig. 7. Map of Barbary where two greens are used the green delineating Hispania is stable while the green in Africa has degraded

ARTIFICIAL AGING STUDY OF THE EFFECT OF MAGNESIUM BICARBONATE ON VERDIGRIS

To mitigate the problems of verdigris it was decided to prepare model samples of some paper with verdigris on them. According to old recipes verdigris was applied to paper with wine, water diluted vinegar, honey and water etc. A small study was carried out by the author to see if the medium in which the verdigris was dissolved or used to apply the pigment to the paper affected the degradation. After aging the samples it appears that all the historic recipes with verdigris resulted in severe degradation and discoloration after aging (figs. 12 & 13). For subsequent studies copper acetate in 5% acetic acid was used to mimic the old recipes.

Fig. 8. Lower left corner of Flandia map showing verdigris damage in transmitted light

Over the years scientific research has shown that small amounts of magnesium bicarbonate is effective in improving the chemical stability of paper with verdigris damage. Shahani and Hengemihle found that a "magnesium bicarbonate wash facilitated the extraction of copper, such treatment extracted, absorbed and/or exchanged species from paper by forming soluble bicarbonate complexes of copper". The work by Gerhard Banik suggested adding magnesium bicarbonate to the size. The fact is that degradation of the paper continues as long as copper ions are present. To determine if magnesium bicarbonate would reduce the paper degradation magnesium bicarbonate was introduced into the paper in three forms. The paper was a pure cellulose water leaf paper. First, magnesium bicarbonate was used in the bath water in which the paper was immersed using a dilute concentration 3-4 grams magnesium bicarbonate per liter solution. Second, magnesium bicarbonate was used in the methyl cellulose size which was applied by brush. Third, magnesium bicarbonate was added to the wheat starch paste used in lining the paper. All the papers were aged at 90° C 50%-RH for 8 days. The photo shows some of the results from aging the samples with the control strip on bottom (fig. 14). The results indicate that papers immersed in bath water with magnesium bicarbonate solution and/or coated with size containing magnesium bicarbonate showed considerably less discoloration.

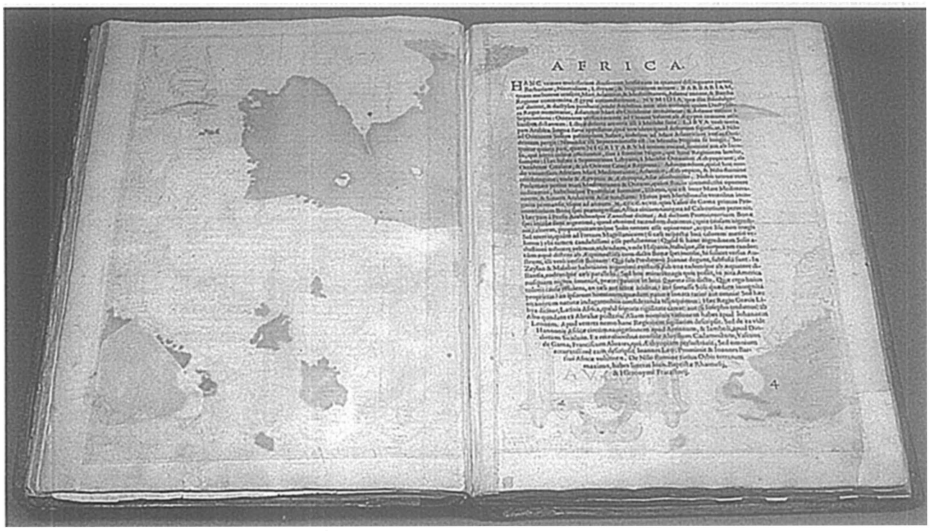

Fig. 9. Map of Africa showing verdigris degradation transferring to adjoining page

DISCUSSION OF STUDY

The study carried out by the author is fairly simple and relies on visual discoloration to measure degradation. More quantitative work needs to be done to measure the amount of degradation, including: testing papers' mechanical

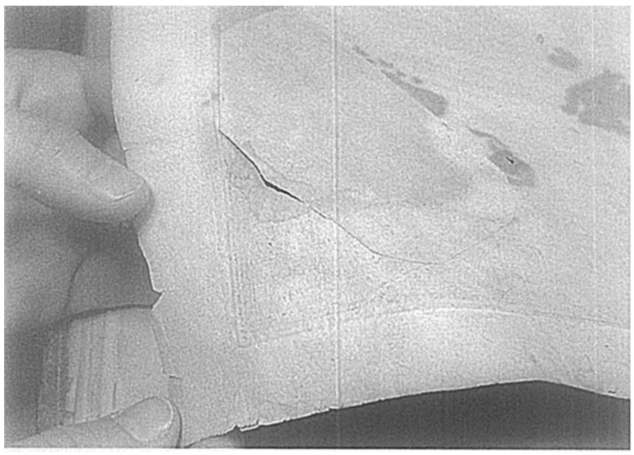

Fig. 10.Verdigris causing embrittlement and cracking during handling

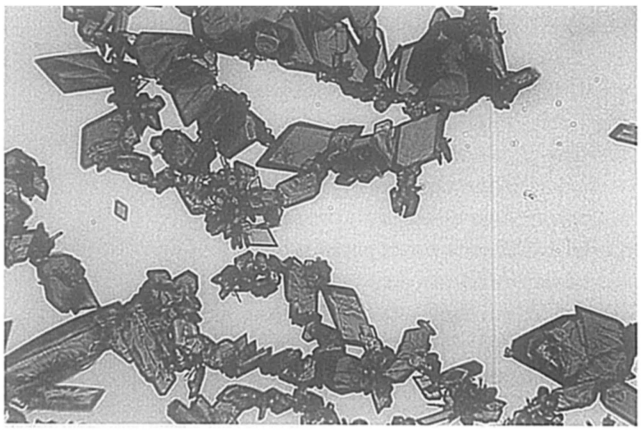

Fig. 11. Copper acetate crystals magnified x20

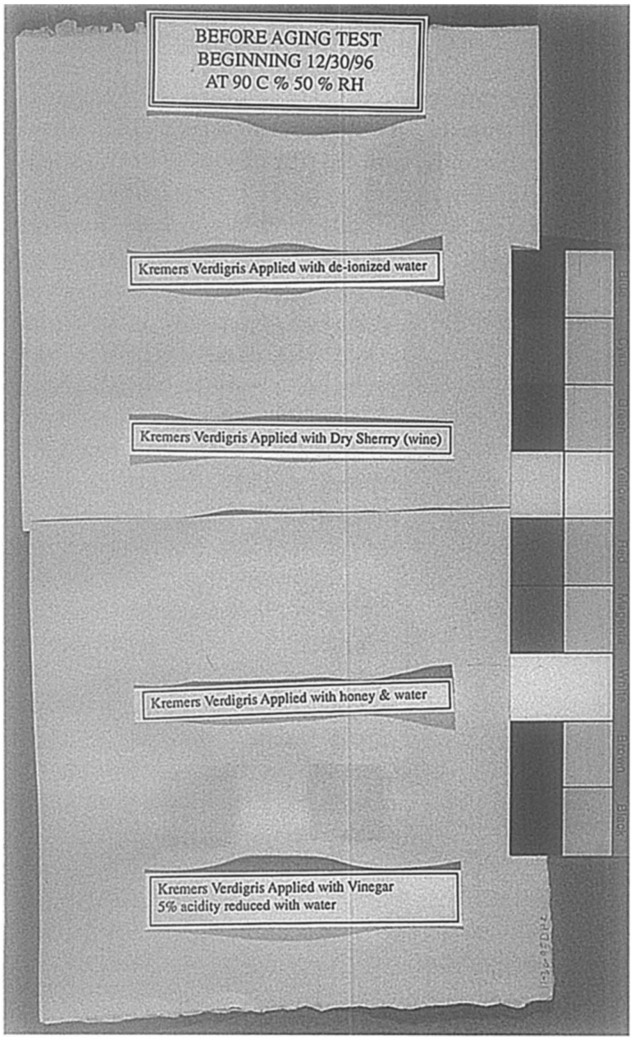

Fig. 12.Copper acetate in various solvents before aging (verso)

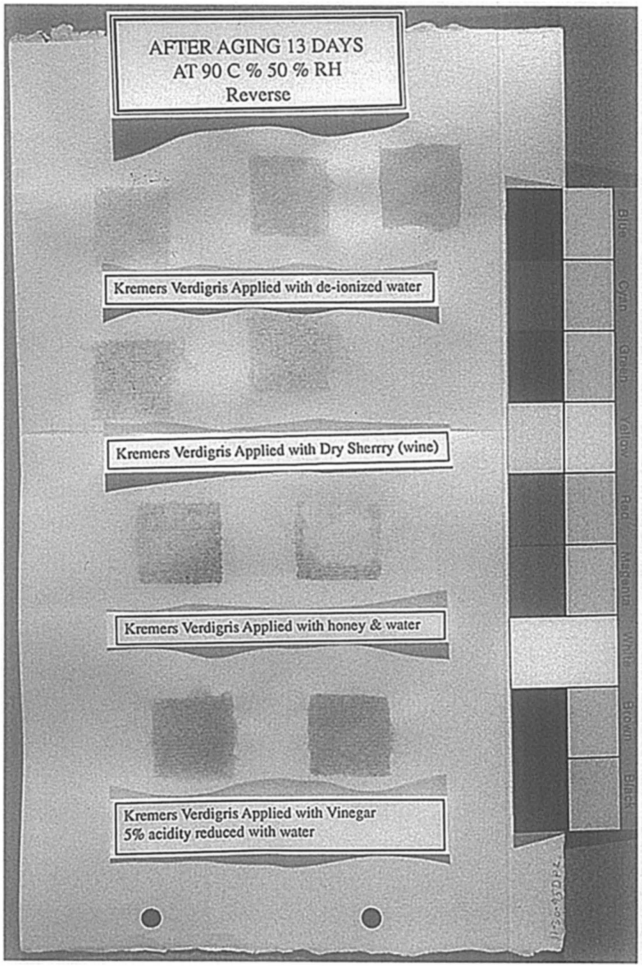

Fig. 13. Copper acetate in various solvents after aging 13 days at 90° F. and 50% RH

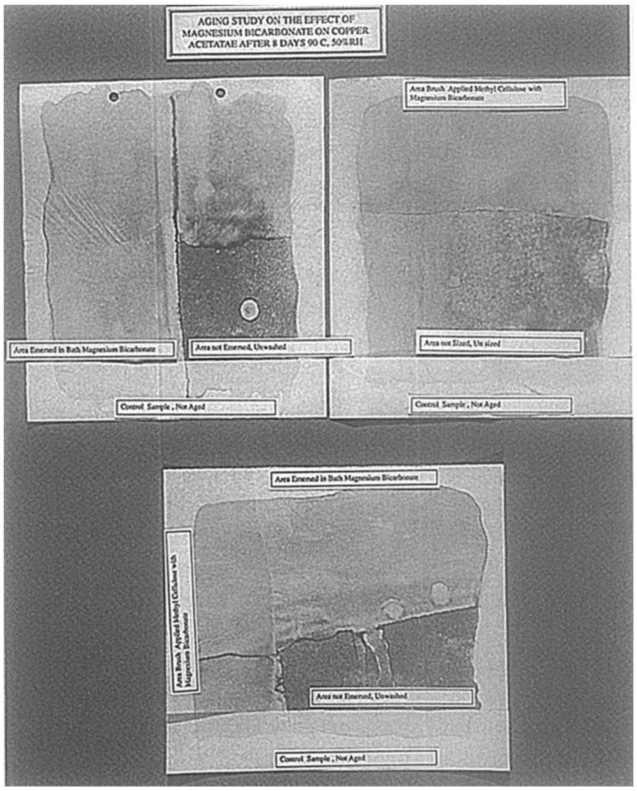

Fig. 14. Effect of magnesium bicarbonate added to wash and size with control strip

strength or tensile strength, after aging. A water extract pH test on the experimental papers would also be useful. Another problem with the study is some copper acetate was washed off or removed from the sheet during application of the magnesium carbonate. Measurement of the copper acetate in the water after washing would indicate what had been physically removed by the washing action. A study could also be done to mimic the atlas pages more closely by aging the verdigris coated paper before applying the magnesium bicarbonate followed by a second aging.

TREATMENT FOR VERDIGRIS EMBRITTLED MAPS

During treatment every attempt was made to minimize any change in the media such as sinking, feathering, or loss of color intensity during aqueous/ solvent treatment. It was fortunate that alkaline sensitive media such as gamboge were not present.

A treatment was designed to both increase chemical stability of the verdigris damaged pages by introducing magnesium carbonate and strengthening the embrittled paper with wheat starch paste linings. A protocol was developed using an initial bath in ethanol to wet up the maps. The maps were then float/immersed washed supported by polyester web (Hollytex) in magnesium bicarbonate, de-ionized water, and ethanol in proportions of 1:2:1. The ethanol water combination limited the access of water to the media reducing potential solubility of the media. This represents about 2-3 grams of magnesium carbonate per liter of solution. The washing also helped reduce soluble deterioration products such as acids and discolored components; removed some of the copper compounds; reduced adhesive residues; and reduced the possibility of tide-lines forming while making repairs. Methyl cellulose A4C (Methocel) size was used to replace size removed during washing and give additional strength to the paper. The size was applied with a Japanese brush.The added benefit of magnesium bicarbonate in the size helped to chemically stabilize the verdigris areas. Twenty-two maps received minor repairs and methyl cellulose size brushed on the paper. Thirty-one maps were lined on the reverse with thin Japanese paper NAO "0". The choice of a very thin, machine made, 'kozo' fiber Japanese paper was based both on strength, and transparency of the paper since the printed text on the reverse of the map had to be legible. One to three linings per map were used to provide physical support to the weak, brittle

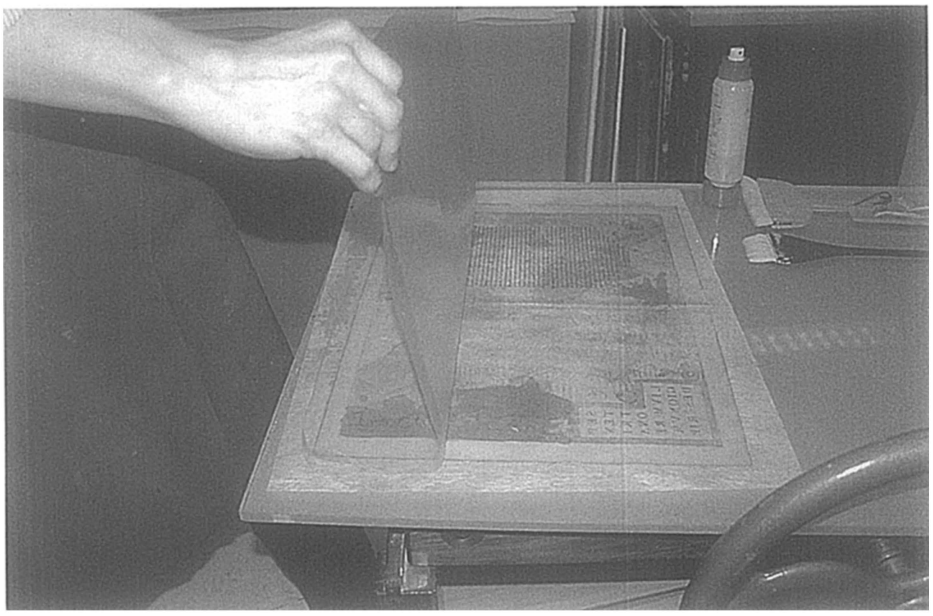

Fig. 15. Lining map with Japanese paper NAO "0" and paste, using polyester film as carrier

paper depending on the extent of the damage. Multiple linings of a thin paper was found to be stronger and more co-operative then a single heavy paper lining. The paper was wet up with a water mister and smoothed out on polyester film (Mylar) before pasting. The polyester film was then used as a carrier (fig. 15). All maps were partially air dried, and finally flattened by drying between felts.

To reduce the possibility of degradation products continuing to transfer from one map to the adjoining page, alkaline interleaving sheets were placed between the pages when the volume was rebound. A hand-made, antique laid paper used for the interleaving supplied by Sea Pen Press and Mill was bathed in magnesium bicarbonate and water bath to bring the dry surface of the paper to 8 - 8.5 pH.

CONCLUSION

In conclusion, the paper through washing, and lining increased the overall stability and allowed the book to be handled and the pages to flow easily. The introduction of magnesium bicarbonate provided chemical stability to the paper by increasing the alkalinity to 8.5 pH and thereby slowing the degradation in the verdigris areas. The introduction of interleaving papers provided a barrier to slow the transfer of degradation products from one page to the next. The rebacking of the book did not alter the appearance of the covers however the interleaving papers increased the thickness of the spine by a third.

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