Conservation of Manuscripts under Local Conditions

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The Herat National Archive's collection of manuscripts is presently kept in the storerooms of the Herat citadel. Thick walls with an open pore structure offer favourable conditions for storage. In order to provide sufficient long-term protection for the manuscripts, regular reviews of their condition and continuous care of the storerooms are required.

Fig. 1 Insect damage in long-fibered, stable paper (HNA 80,15th /16th century)

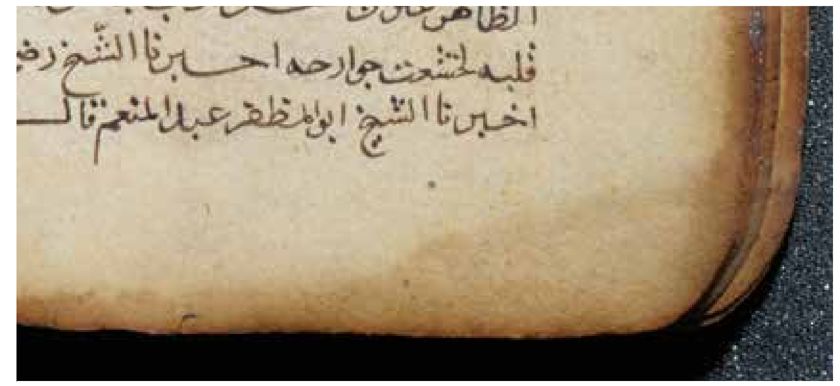

Fig. 2 Paper with old water stain and newer traces of fire and probably fire-fighting water (HNA 53, dated 1340-41)

The majority of manuscripts consists of natural, organic material, whose own moisture content constantly interacts with its surroundings. If we wish to preserve them, these manuscripts require effective protection from their natural ambient conditions. When exposed to natural factors such as humidity, moisture, light, warmth, heat or – in its most extreme form – fire, these elements can trigger physical, chemical and microbiological processes, which ultimately decompose the organic matter of the manuscripts. Bacteria and mould are the microbiological stimulants in this process. Furthermore, insects as well as mammals such as mice and rats also benefit from the nutritional resource of these cultural possessions (Fig. 1). In places where several of these factors endanger cultural heritage, it may decompose and its substance may be returned to the natural cycle (Fig. 3). In order to prevent such attacks, every culture has developed its own strategies for the protection of cultural heritage. Today, one branch of the domain of conservation and restoration, preventive conservation, deals with these issues. Over the last decades and on the basis of results from applied, mostly industrial but also conservation science, processes of change as well as degradation of matter gained from organic nature could be distinguished and explained and, thereby, methods for the protection of such materials were developed.

Scientific knowledge of the conditions which led to the preservation of large amounts of cultural possessions of vegetal or animal origin over centuries or, in some cases, millennia is still incomplete. Much of the practical

Fig. 3 Insect damage throughout the book, unfinished manuscript without outlines (HNA 125, 17th century)

◄ *Cover of courtly codex (HNA 11), detail* knowledge, such as the extent to which the fireproof quality of HNA 53 from the 14th century was lost or has, as we realised when examining the state of the Herat collection, fallen into oblivion (Fig. 2). The Herat collection of manuscripts offers the opportunity to rediscover some of this forgotten knowledge and, for the purpose of further storage or presentation of the collection, to combine it with the latest recognitions in long-term storage of natural, organic materials.

The methods of actual conservation-restoration of the Herat manuscripts are, with regard to existing historical restorations, integrating these into the current methodological potential. Where mechanical and chemical processes of degradation endanger the collection of manuscripts, these processes are slowed down with conservational means as far as possible or even brought to a halt, and further mechanical damage caused by the use of the objects is prevented if possible. The conservation of any book-archaeological traces, which include earlier restorations, requires minimised interventions (Fig. 4). Prominent examples of manuscripts are preserved according to their formal aesthetic perception. For this comprehensive work specific methods adapted to the aesthetics of book art had to be developed. Here, the focus was in particular on the formation of paper reinforcements as thin and stable as possible for the centre folds. We achieved satisfactory results with modified thin Japanese Kozo papers (Fig. 5). The sequence of conservational measures was conducted according to the following aspects: documentary safeguarding of the collection's continued existence, conceptual development, cleaning, consolidation and restoration of the bookblock and, in the end, the reattachment of the cover. These measures are discussed in the second part of this contribution.

Preservation in Local Conditions

Material and Ambient Conditions

The materials used in book art were made from organic matter of animal and vegetal origin. Water is an integral part of all these materials; up to a certain amount it is strongly bound to the material's polymer chains and keeps them flexible (Fig. 6).[1] If more than this bound water is adsorbed by the material, these water molecules will behave like they usually do: As they are minute and physically practically unstoppable, they will feel free to move unhindered in one or the other direction following the physical law of balancing the water vapour pressure inside and outside the material. Since a manuscript can adsorb water vapour very quickly, accumulation of humidity in the paper is not necessarily ascertainable with simple measurement technology. Therefore, for the protection of this category of heritage the observation of material behaviour within its environment and accurate planning of storage and potential presentation are all the more important. If this fact is not recognised, it can happen that precious manuscripts contribute unnoticed to the air-conditioning of a display cabinet, instead of being protected from vapour pressure fluctuation.[2]

1 Banik/Brückle 2011, 268–269.

2 Florian 1997, 7.

Fig. 4 Consolidation of brittle paper along the spine with modified paper of Kozo-fibres, the wheat starch paste still wet (dark) (HNA 124, dated 1776)

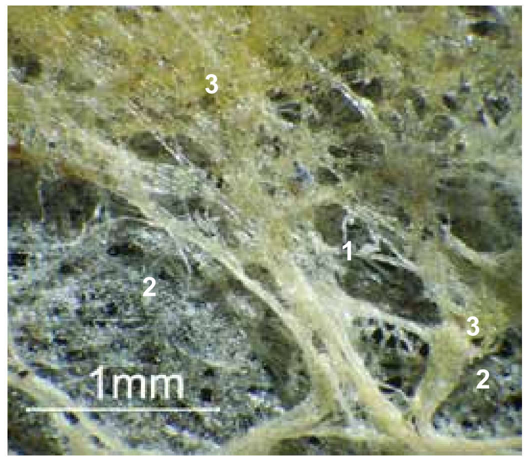

Fig. 5 Japanese handmade Kozo papers, adaption to the surface of Islamic papers by reducing its porosity (1); colourless (2) and pigmented (3) fillings: 0.02 mm thickness

Fig. 6 Fibre from fore-edge: complete fibre with no flexibility (1) and many residues on the surface (2), possibly damaged and dried out by heat (see Fig. 3) (HNA 53, dated 1340)

In the city of Herat, where due to constant wind neither industry nor traffic pollute the air to an extent that might endanger the Museum's inventory of books, we can completely restrict our considerations about the storage of manuscripts to the close relation of temperature and humidity. Frequent changes in humidity levels cause physical fatigue of the material's microstructure through constant swelling or shrinkage. Overly high or alternating moisture contents make organic matter attractive for food-seeking micro-organisms and insects and trigger their development.[3]

The value of relative humidity (RH) is solely related to the maximum absorption capacity of the air at exactly one specific temperature. If the temperature rises in a vapour proof display cabinet, RH will fall; if the temperature falls, RH will rise. For example, air at 20 °C contains 8.7 g/m^3 vapour, which corresponds to a relative humidity of 50 % RH. The dew point, that is the point at which the maximum of 100 % RH is reached with these 8.7 g/m^3, is slightly above 9 °C. At 20 °C a maximum of 17.3 g water vapour per cubic metre can again be absorbed by the air, which corresponds to 100 % RH.

If we imagine an atmosphere at 20 °C saturated with water vapour in a vapour and gas-proof glass cube of 1 m^3 and then reduce the temperature within the cube by only 1 °C, there will be precipitation of 1 g condensation in the glass, as from 17.3 g/m^3 water vapour only 16.3 g/m^3 can be retained at 19 °C. At 15 °C it would be only 12.9 g/m^3 that could be retained; 4.3 g would condense on the cube's glass. For the storage of natural organic matter humidity values of approx. 45 % RH are recommended at 19 °C to 20 °C, which corresponds to a vapour weight of 7.4 to 7.8 g/m^3 air. If we once again imagine the glass cube and reduce the temperature from 20 °C and 7.8 g/m^3 to 15 °C, the value will rise from RH to 61 %, because the vapour weight of 7.8 g/m^3 has remained identical.

In a second experiment, if we place a stack of unlined paper, cardboard or even textiles in this cube and maintain the temperature at 20 °C and 45 % RH for several weeks and then reduce the temperature to 15 °C, the paper will adsorb water vapour with the decrease of temperature. The glass cube will level off fairly quickly at approx. 45 % RH corresponding to 5.8 g/m^3 vapour weight. No condensation develops, because the vegetal materials have balanced the system.[4] It is essential to prevent cultural assets from natural organic matter from taking on this sort of functions.

Even more dangerous than in the display cabinet is the situation of transporting objects from one climate to another. If a manuscript is taken from a place with a temperature of 33 °C and relative humidity of 47 %, therewith a vapour weight of 16.8 g/m^3 and a dew point of 20.2 °C, to the storerooms, where the temperature is not higher than 19 °C, this is a serious threat to the object's condition: the temperature falls below the dew point, which, in theory, can result in humidity formation in the manuscript. As we will observe below, the capacity of moisture retention of the Herat manuscripts has already been consciously reduced in the manufacturing process. It can therefore hardly be predicted how they would respond to such a climatic change.

A good condition of organic manuscripts necessarily requires temperature and vapour pressure conditions to remain as constant as possible. Ideally books are protected from abrupt changes by a system of numerous layers of covers, ranging from the walls of the deposits, the cupboards, boxes and cases, in which the books are stored, to the book covers within the cases. All these factors serve the purpose of slowing down humidity changes in the originals to be preserved, and therewith also of repelling insects and micro-organisms.

Storage Facilities

The Herat collection of manuscripts is housed in two large rooms, one front room adjacent to the courtyard, and one back room that is integrated in the building complex. Both rooms with their thick, open-pore masonry offer stable climatic conditions and are suitable for protecting the collected manuscripts. An oblong room, which leads like a wide hallway along the front storeroom to the back one, serves as a kind of air lock between the storerooms and the out-of-doors. Only the back storeroom is connected to the outside by roof lanterns.

Just a few days of climatic measurements taken from April to May 2012 may give an impression of the climatic situation of the two storerooms. At that time the outdoor climate was regular with constantly warm days and somewhat cooler nights. No influence of the outside temperature on the conditions in the room could be noticed inside the back storeroom; the climate remained stable with a temperature of 19 °C to 22 °C and a vapour weight of 8.2 to 8.7 g/m^3. The absolute amount of water present was similar in the front storeroom: there, at a temperature of 24.3 °C, a relative humidity of 32 % was measured, which corresponds to a vapour weight of approximately 7.2 g/m^3.

In order to assess the conditions correctly, a door to the back room was left open for several hours; the results were reassuring: one data logger in one of the collection boxes showed a gradual temperature increase to 28 °C; one hour later the temperature had reached a maximum of 29 °C and a humidity of 32 %, which corresponds to an increased water vapour content of

3 Florian 1997, 7.

4 Based on a similar exemplary model by Florian 1997, 7.

Fig. 7 View of the book art exhibition

9.3 g/m^3. When the door was subsequently closed, the temperature in the box decreased within 30 minutes to 24.7 °C, and the relative humidity to 37 %, which in turn corresponded to only 8.4 g/m^3, that is the standard amount of vapour for the storerooms. Closing the door has testified to the capacities of the storing material, the cardboard and the thick walls of the depository for ensuring a rapid equalisation of vapour pressure. The raised amount of water coming in with the hot air in the course of the cooling process after closing the door was quickly absorbed inside the room and slightly delayed by the cardboard, with the result that after 30 minutes the same amount of water vapour was measured as before.

In the front storeroom the collection of manuscripts could be permanently well ordered, placed and locked in steel cabinets. Wooden cabinets made of chipboard finished with imitation wood veneers would have been available; however, they were rejected in view of their content of organic acids. These can have unfavourable effects on some pigments and the paper of the books when they evaporate. Steel cabinets are free of such contents; their lack of climate-protective, absorbable materials was compensated with cardboard and, wherever space remained, additional low-fired bricks from the construction site at the Herat citadel.

During the archaeological restoration project in 2009 the manuscripts were wrapped in water vapour permeable polyethylene fleece[5] and, except for a few volumes, placed in archival book boxes.[6] These packing materials are consistently stable and intended for long-term storage. At the end of the project especially sensitive and endangered manuscripts and single sheets were additionally wrapped in 'gampi paper'[7], a special paper consisting of a bast fibre that cannot be damaged by humidity, moisture and insects. The lacquer covers also were to be wrapped in thin paper, because at high temperatures short polymer chains can escape from the polyethylene of the Tyvek material and possibly soften the lacquer.

Within the framework of the provided conditions the books are stored safely for a long period of time. Nonetheless, continuous control of their state and cleaning the storerooms and cabinets are imperative and should be carried out several times a year.

Exhibition

With the reopening of the permanent exhibition in the Herat National Museum in autumn 2011 the collection's major manuscripts were presented to the public for six months before being safely deposited again in early summer 2012. For the duration of this exhibition and future exhibitions of the manuscripts as well, it was considered necessary to create climatically stable conditions in the showrooms.

The rooms of the Museum in the Herat citadel run along the north side of the courtyard of the lower portion and are oriented towards the south. The rooms chosen for displaying the manuscripts were installed without windows in the 2nd floor of the museum complex and are thus hardly affected by this situation; natural light enters only indirectly from the adjacent rooms. The exposed brickwall surroundings and the vaulted ceilings as well as the clay floor covering are porous and have maximum potential for keeping the rooms cool and for regulating the climate due to their sorption capacity. Moreover, wooden cabinets made by Herati carpenters provide protection for the exposed books against theft, light and sudden climatic change.

On top of the showcases a sloping, lectern-like glass cover allows view of the manuscripts on display (Fig. 7). Fluorescent tubes are installed in a wooden case incorporated in the glass lid; their bright light reveals every detail of the manuscripts and miniatures on display. The heat radiating from the tubes is drawn off through ventilation slits in the lighting cases above the showcases.

For exhibition purposes the manuscripts are mounted on cardboard and then inserted into the showcases through a sliding glass door that opens in the front. This altogether good conservational situation still presented three major problems for the manuscripts that had to be solved. These were: (1) the emission of organic acids from the wood and protective coatings; (2) the insufficient sealing of the showcases, which would have allowed insects, such as the abundant silverfish, free access to the books; and (3) the fluorescent tube separated from the manuscripts only by the glass cover. Namely, the tube emits alarmingly high portions of UV radiation that can affect the manuscript pages. Furthermore, for climatic reasons a considerable amount of adsorptive material had to be placed inside the showcases, as the wood's adsorptive capacity was reduced by the protective coating. In order to enable the best possible perceptibility of the manuscripts, a subdued background with light reflection in depth had to be created for aesthetic reasons.

ad 1: Against the effects of emissions from the wood, bare carbon fleece was laid across the interior of the showcases. With its expansive inner surface, it adsorbs the Volatile Organic Compounds (VOCs). According to information from the merchandiser, the product chosen for this purpose has an extensive adsorption capacity of 1000 to 1200 m^2/g.[8] However, within the system is also the danger that due to saturation the adsorptive capacity decreases at some point and the absorbed substances can no longer be kept in the warmth by the carbon in sufficient amounts, especially at rising vapour pressure, and thus can be emitted again. Therefore, as a precaution, the carbon fleece was covered with a natural white cotton cloth and a pure, 1.65 mm thick cotton cardboard[9] as a base upon which the manuscripts were placed. Possible gaseous emissions can thus be adsorbed and, through a possible chemical reaction, also be absorbed by the cotton cloth and cardboard. For the purpose of protecting the manuscripts, these materials increase the sorptive potential inside the showcases.

ad 2: The wooden frame and the sliding door were sealed, the latter with a piece of transparent PE-tube, as a measure against the danger of insect intrusion into the showcases.

ad 3: The radiation of blue and nearby UV light from the floodlights in the room and from the fluorescent tubes of the showcases affecting the open manuscript pages is only partially absorbed by the glass. There are two possibilities for reducing the effects of energy from light rays on the very susceptible historical material: either the distance between the source of radiation and the object can be increased, or the radiation interfering with the material structure can be scattered, on one hand, and, on the other, reflected or absorbed. Absorption means that the effect is limited in time by corresponding changes in the absorbent. Protection from the high UV proportion of floodlights that illuminate the entire room can be sufficiently provided by using a UV-protective coating, because the lights are installed at a distance of 2.5 to 4 m from the showcases. The fluorescent tubes in the showcases themselves were purchased intentionally in this form, so that they can readily be obtained on the local market. They radiate very directly on the paper, despite the scattering effect of the glass tube. Already doubling the distance would allow ¼ of the energy to affect the objects; with a quadruplication it would only be 1/16. In our case this was not possible, so in addition to the protective foil, which loses its protective function rapidly when exposed to energy, the light must be scattered and absorbed. Titanium white in rutile form was bound and applied in a small amount of cellulose ether to the first roughened UV-protective foil and loosely wrapped around the tubes. Titanium white reflects and scatters light to a maximum extent, providing good lighting at a strongly reduced energy input for the manuscripts. In its rutile form titanium white shows a slight decrease in reflection in the blue and near UV range.[10] The radiation is immediately absorbed and gradually causes decomposition of the binding agent, cellulose ether, and the pigment, titanium.[11] With regard to the burning time of the fluorescent tubes in the Herat National Museum, this process appears, even in the course of so many years, to be of no great relevance, so that nothing speaks against this solution for the problem. The development of radicals as decomposition products of this process, caused by UV energy absorption, is irrelevant in this solution we found, because these radicals are dissipated outside the showcase.

The cotton cloth combined with the cotton cardboard as lining material for the showcases, assured a subdued background. In order to avoid warping caused by seasonal climatic changes, the soft uncoated cardboards were joined without stress through a kind of adhesive tiling: adhesive tapes coated with dextrin were pasted alternating with and against the direction of the grain of the tape. In addition to its rapid and highly sorptive capacity the cotton cardboard offered a similar light effect as the manuscripts themselves, which however remains very discreet because of the lacking coating. Thus, the aesthetic requirements could be fulfilled as well. Thanks to the latest, fully developed conservational instruments and accurate modification, climatic and lighting technological protection adjusted to the actual needs of the manuscripts could be achieved in the showcases built on the spot.

5 Tyvek® Company DuPont, acquired from Deffner & Johann GmbH, 97520 Röthlein, Germany.

6 These book boxes are made of adhesive-free, corrugated archival cardboard produced according to DIN / ISO 9706 norm acquired from Klug-Conservation, Walter Klug GmbH & Co. KG, 87509 Immenstadt, Germany.

7 Williams 2013.

8 CCI activated charcoal cloth Zorflex FM10, unlined, c. 1000 to 1200 m^2/g, acquired from C. Waller, long life for art, Germany - http://www.cwaller.de.

9 100 % select cotton fibres, 3 % calcium carbonate buffer, acquired from Anton Glaser, Feinpapier-Großhandel, Germany - http://www.anton-glaser.de/index.html.

10 Kittel 2003, 40.

11 Hering 2000, 201.

Fig. 8 *Shamsa, detail f. 1a: loss of gold and paint by fire (loss of painted surface and black, and above, ochreous overpaint[1]), degraded paint, craquelures (greyish white paint in upper part [2]), loss of red lacquer (right lower edge [3]), brittle, split paper (tears [4]) (HNA 107, dated 1272)*

Fig. 9 *Edge of folio, brittle paper, caused by iron content; glue of paper-sizing was reactivated by entering water stopped through the swelling effect (small water stain along border [1]); after separation from next folio (loss of paper surface within water stain [2]) (HNA 18, 17th century)*

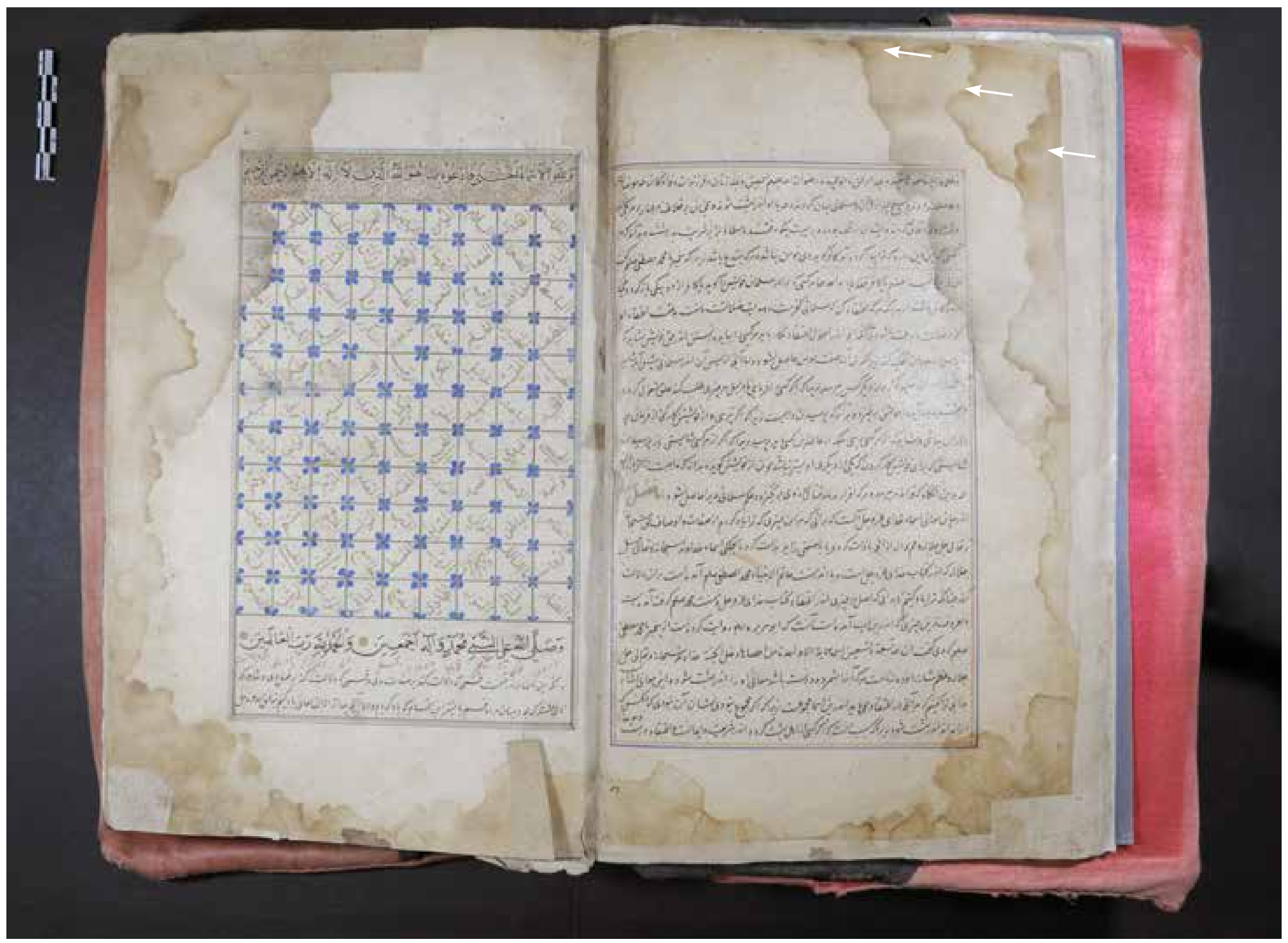

Fig. 10 *Accumulation of brown degradation products and possibly colour along multiple water stains (HNA 78, f. 6b–7a, late 17th/18th century)*

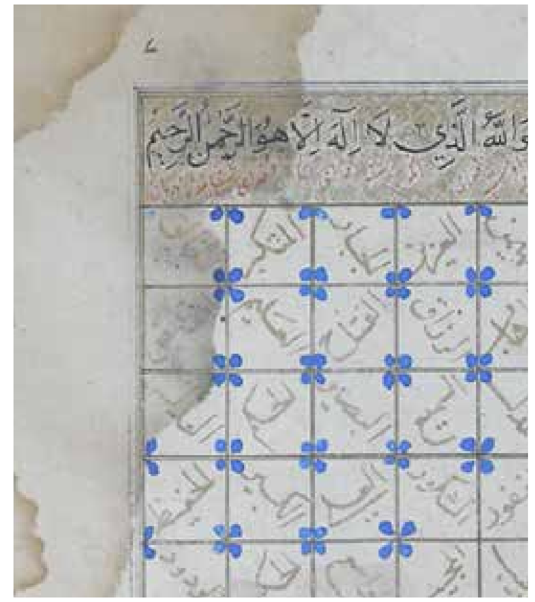

Fig. 11 *Detail of Fig. 10: fine ink pigments transported by water to the front, where fine crystals can be observed (HNA 78)*

Fig. 12 *Only a minute amount of the bold ultramarine line (1) was transferred to the opposite folio through water damage (2); black shiny silver thread in endband (3) (HNA 67, fs. 1b–2a, dated 1492-93)*

Material Immanent Protection, a Quest

Little is known today about the Herat collection of manuscripts. Nonetheless, the collection is well preserved in its basic material substance, although traces of fire and water can be detected on some parts (Figs. 2; 9–11). Moisture connected with paper fibres, starch and other carbohydrates in the coating and binding agents would usually result in pages stuck together, mould, rot and insect damage in the manuscripts. Even if one can envision how the great esteem of book art in Herat and the courageous efforts of individuals could continuously prevent further damage to the collection, the stable condition of the material in most of the manuscript papers is nevertheless astonishing and not explicable at first glance. In places where the paper is brittle as in the 18th century manuscript HNA 124 (Fig. 4) and Holy Qur'an HNA 18 (Fig. 9), the cause is obviously not connected with water damage.

During the conservation project it could only be suspected that, in the manufacturing process of the manuscripts, some preventive measures had been taken against the effects of high humidity and moisture and the subsequent microbiological processes. In order to verify or deny this, the methods involved were examined according to the condition of the paper and calligraphy as well as the mode of entry and distribution of water.

Fig. 13 *Water stain underneath the surface; slow entering of water from nearer edge, fast from top edge (HNA 66, dated 1691)*

The ink applied to the burnished surface of the manuscript pages was smeared only in a few of the collection's Persian manuscripts that had been damaged by water: The line's convex relief shape produced by the stroke of the reed pen, caused by the influence of moisture, has seldom rubbed off on the corresponding opposite page as the blue line in the 15th century manuscript HNA 67 (Fig. 12).

Penetrating moisture spreads widely on the folios of some closed books as in the late 17th century manuscript HNA 66 (Fig. 13). Compared to other experiences with paper this phenomenon reminds of the narrowing of capillaries. The process of water flowing through the inside of the paper