Technology and Pathology of Salting Woven Carpets, Iranian Carpet Museum

Mina Karimi
M.A. Graduate in Conservation of Cultural and Historical Objects, Department of Conservation of Cultural Properties, Faculty of Conservation and Restoration, Art University of Isfahan, Iran/ minaakarimi1987@gmail.com
Hamidreza Bakhshandehfard
Associate Professor, Department of Conservation of Cultural Properties, Faculty of Conservation and Restoration, Art University of Isfahan, Iran. (Corresponding Author)/ hr.bakhshan@aui.ac.ir
Mehdi Ebrahimi
Visiting Lecturer, Carpet Department, Art University of Isfahan, Isfahan, Iran/ Mehdi_19_60@yahoo.com

Received: 02/05/2025
Accepted: 23/08/2025

Introduction

The Safavid period (1501–1722 CE) marks the golden age of Persian carpet weaving, enabled by political stability, economic prosperity, and royal patronage. Workshops in cities such as Isfahan, Kashan, Tabriz, and Kerman produced masterpieces now preserved in major museums (Pope & Ackerman, 2008). 'Salting' carpets— named after an English collector, George Salting,and crafted in 16th–17th century Safavid royal workshops— feature vibrant colors, dense knots, silk and wool foundations, silver-gilt threads, and designs, including medallions, mihrab, arabesques, and inscriptions. Iranian specimmesn are notable for their finesse and quality. Over time, environmental exposure, poor handling, and improper cleaning have caused fading, silk degradation, metal corrosion, and localized damage. Technical studies including fiber and dye analyses reveal their materials, weaving techniques, and historical context while they provide crucial insight for effective conservation and preservation strategies.

Research Method

The study focused on a late Safavid gilt-metal (Golabatun) medallion carpet, attributed to Tabriz, measuring 302×166 cm, with a corner-medallion (Lachak-Toranj) design, quarter field, and Nastaliq inscription. The carpet combines wool, silk, and silver-gilt threads, woven with symmetrical knots, and features main colors of red, navy, pistachio green, and orange. Despite previous restoration, the carpet exhibits damages including tears, stains, wear, and burn marks. Acomparative analysis with Safavid-period carpets was conducted to confirm dating, origin, and artistic features.Fiber sampling was minimaland including representative pile colors, warp, and weft, taken from deteriorated or loose areas to avoid damaging intact regions. Samples were coded and stored in sterile containers. Fiber identification combined microscopy, chemical tests, and burning analysis. Microscopic examination of longitudinal and cross-sections identified wool, silk, and cotton fibers, supported by chemical tests (NaOH for proteins; lead acetate for cellulosics) and combustion behavior. Sizing on the support was verified using Molisch and iodine-starch tests.Golabatun threads were analyzed using digital loop microscopy for surface wear, breakage, and corrosion, and SEM-EDS to determine chemical composition and structure. Nitric acid tests confirmed the presence of silver and trace copperalong with gold surface gilding verified by SEM and FTIR spectroscopy of the silk core.Weave structure was examined by counting knots, warp, and weft density; knot type and arrangement were also documented. Color identification involved preliminary chemical tests followed by FTIR spectroscopy to detect mordants and pigments.Conservation tests assessed fiber stability and sensitivity; aqueous swelling measured dimensional changes after wetting and drying; colorfastness tests evaluated resistance to light and humidity, and color transfer tests verified that washing would not leach dyes. These combined methods provided a comprehensive assessment of the carpet's materials, structure, and conservation requirements while ensuring minimal damage during sampling.

Research Findings
The Salting gilt-metal carpet from the Carpet Museum of Iran exhibited an asymmetrical (Persian) knot structure, a “Lool” weaving technique, silk warp and weft, fine wool pile, and gilt-metal (Golabatun) decorations with a silk core. Colorants were entirely natural and plant-based. Weaving density was measured at approximately nine knots per centimeter (about 60 knots per 6.5 cm), reflecting the weavers’ skill and precision. Microscopic examination confirmed the use of asymmetrical knots, with S-twist wefts and Z-twist Golabatun threads. The back curvature and warp arrangement indicated the “Lool” technique typical of Azerbaijani weaving, particularly Tabriz, which produced prominent knots visible on the reverse side. The Golabatun sections showed metallic strips wrapped around silk threads, creating a fabric-like effect. Fiber identification showed that warp, wefts, and supplementary weft threads were silk, while the pile was wool. Longitudinal and cross-sectional microscopy confirmed tubular, smooth silk and cylindrical, scaly wool fibers. Chemical tests with 5% NaOH and lead acetate corroborated these findings. Support threads included cotton and wool, with characteristic thermal and morphological behaviors. Golabatun threads were found to consist of silver coated with gold, with minor copper content, which was confirmed via microscopic, SEM-EDS, and chemical analyses. The gold layer is more concentrated at the exterior, serving as both decorative and protective coating. FTIR analysis identified natural dyes: indigo for blue, a combination of madder (Rubia), and approximately 10% cochineal for red, mordanted with white alum. Sizing analysis, using the Molisch and iodine-starch tests, confirmed the presence of starch-based carbohydrate sizing. Damage assessment revealed extensive deterioration due to environmental, chemical, biological, and mechanical factors, including color fading, pile wear, warp/weft breakage, moth damage, and previous restoration issues. PH measurements indicated acidic conditions (mean $pH \approx 5$), promoting fiber degradation. SEM-EDS results showed corrosion of Golabatun fibers, with silver sulfide and chloride layers forming due to environmental exposure. Conservation tests demonstrated that aqueous washing did not cause fiber swelling or color transfer, confirming the method’s safety. Preventive measures, including controlled humidity (40–55%), stable temperature (18–21 °C), UV-free LED lighting, and display in ventilated laminated glass cases, were recommended to stabilize and protect the carpet while allowing optimal viewing.

Conclusion
The Salting gilt-woven carpet featured a Persian knot, a lul weaving technique, silk warp and weft, and fine wool pile. It was decorated with golabatoon threads made of gilded silver with a silk core;all dyeswere natural and plant-based. Damage analyses of the carpet and its support indicated acidic conditions, weakness and deterioration of silk fibers, and corrosion of metal decorations caused by environmental factors such as light, humidity, and airborne pollutants. Mechanical damages,including fractures, compression, and tears that resulted from improper storage and past restorationsfurther contributed to structural degradation. Wet-cleaning and colorfastness tests confirmed that a controlled washing method was safe. Based on these findings, a conservation plan was designed following the principles of minimal intervention, reversibility, and material compatibility, including the removal of acidic supports, controlled surface cleaning, reinforcement with compatible backing, and limited repair of previous losses.

Keywords: technology, pathology, salting carpet, Iranian Carpet Museum.