ABSTRACT: This project investigates the materials and techniques used by Tibetan artists. Six Tibetan thangkas were analyzed by infrared reflectography, energy dispersive x-ray fluorescence, Fourier transform infrared microspectroscopy, Raman spectroscopy, scanning electron microscopy-energy dispersive spectroscopy, and high-performance liquid chromatography. The analysis has suggested that three thangkas of the eighteenth-nineteenth century have a traditional palette, which includes azurite, vermilion, orpiment, bronchantite, red lead, dolomite, magnesite, organic red with calcite or magnesite substrate, and alumino-silicate clay minerals. Another late nineteenth or early twentieth century thangka shows the use of Western pigments such as emerald green, ultramarine, calcite, gypsum, chrome yellow, gold color from brass powder, and red and yellow dyes with barium sulfate substrates. Two twentieth century thangkas made for the tourist trade revealed a twentieth century palette such as titanium dioxide, phthalocyanine blue, phthalocyanine green, and other pigments such as red lead, chrome yellow, barium sulfate, and gypsum.

Introduction

A Himalayan thangka, or rolled-up image, is a sacred painting (Figure 1) in opaque distemper that has a complex mount of textiles and hanging dowels (Figure 2). The production of Tibetan Thangkas has been influenced greatly by Buddhist nomadic monasticism and cultural exchange as well as economic exchanges between Tibet and the neighboring Himalayan countries. The scientific examination of twenty-five thangkas have been previously published (twenty-three 17th century Tibetan thangkas<sup>1</sup>, <sup>2</sup>, <sup>3</sup> and a 15th century Nepali thangka<sup>4</sup> and an 18th-19th century Bonpo Tibetan thangka<sup>5</sup>). Currently, studies on the introduction of synthetic and Western pigments into Tibet are ongoing at Winterthur and the Philadelphia Museum of Art. This study, a collaborative effort between conservators and museum scientists, examines the evolution of Himalayan thangka painting materials through the analysis of six thangkas dating from the 18th through the 21st centuries. Special attention was given to foreign trade from China and India, which directly impacted the availability of artists’ materials in Tibet via local trading routes. The six Tibetan thangkas were selected to represent the evolution of the artists’ palette in Thangka production: one from eighteenth century, two from eighteenth to nineteenth centuries, one from late nineteenth century or early twentieth centuries, and two from the late twentieth or early twenty-first century.
Methodology

Analytical methodology included the use of energy-dispersive x-ray fluorescence (ED-XRF), Fourier transform infrared microspectroscopy (FTIR), Raman microspectroscopy, Liquid Chromatography - Diode-Array Detector- Mass Spectrometry (LC-DAD-MS) analysis, Fibre Optic Reflectance Spectrometry (FORS), and scanning electron microscopy-energy dispersive spectroscopy (SEM-EDS).

Description of the Thangkas and Analytical Results

Thangka A (Figure 3, left):

The earliest thangka studied, dating from the 18th century. It is thought to be from either Lhasa or eastern Tibet. It depicts two Arhats, one of the attendants (Hvashang) and two of the Guardian Kings. Analysis has identified dolomite in the ground as well as cinnabar as a red pigment (Figure 3, right).

Thangka B (Figure 4, left):

This thangka, from the 18th-19th century, is thought to be from the Tsang region of Central Tibet. It is from a Gelugpa context, and depicts Sakyamuni surrounded by Gelug teachers. Analysis has shown the presence of antlerite and brochantite (Figure 4, right, top). Significant quantities of arsenic suggests that orpiment was used as a yellow pigment. (Figure 4, right, bottom).
Figure 3: Left: Thangka A.
Right, top: FTIR spectra of dolomite in ground.
Right, bottom: Raman spectrum of red pigment: cinnabar is identified in the sample.

Figure 4: Left: Thangka B.
Right, top: FTIR spectrum showing presence of antlerite and brochantite.
Right, bottom: XRF spectrum suggesting use of orpiment as a yellow pigment.
Thangka C (Figure 5, left):

This thangka is from central Tibet, and depicts Amitabha surrounded by Sukhavati pure land/paradise, late 18th to 19th century. Its paint layer which contained a bright orange pigment, was partially masked by soot deposits (Figure 6). The green pigment malachite was identified (Figure 5, right). The green color in the silk mount was analysed and found to be a mixture of blue and yellow colorants: indigo and rutin (Figure 7). The exact Himalayan plant sources for these dyes are not known; perhaps they were imported.
Figure 7: LC-MS-DAD analysis of the green silk mount in Thangka C. Indigo (blue) and rutin (yellow) were identified.

<table>
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<tr>
<th>Peak</th>
<th>Retention Time (min)</th>
<th>UV max (nm)</th>
<th>Mass [M-H]^- (Da)</th>
<th>Possible compound</th>
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<tr>
<td>1</td>
<td>26.7</td>
<td>354</td>
<td>629</td>
<td>Rutin (Quercetin 3-rutinoside)</td>
</tr>
<tr>
<td>2</td>
<td>29.4</td>
<td>344</td>
<td>623</td>
<td>Unidentified flavonoid</td>
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<tr>
<td>3</td>
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<td>261</td>
<td>Indigotin</td>
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<tr>
<td>4</td>
<td>46.8</td>
<td>546</td>
<td>261</td>
<td>Indigotin</td>
</tr>
</tbody>
</table>

A: HPLC profile, Sample 4579, green, formic acid extraction
B: UV/Vis spectrum of peak 1 (rutin)
C: UV/Vis spectrum of peak 3 (indigotin)

Figure 8: Left: Thangka D. Right, top: Cross-section photomicrograph of chrome yellow applied over ultramarine blue (visible light, 200x magnification). Right, bottom: ED-XRF data of green colorant, revealing Cu and As.
Thangka D (Figure 8, left):

This is a mid-20th century thangka depicting Tsonkapa, founder of the Gelug lineage, possibly of Mongolian or Sino-Tibetan/Amdo, in the folk art tradition. The cross-section photomicrograph (Figure 8, top right) shows chrome yellow applied over ultramarine blue. ED-XRF analysis (Figure 8, bottom right) of a green colorant revealed the presence of copper (Cu) and arsenic (As). This data in conjunction with FTIR analysis indicated the use of emerald green pigment.

Thangka E (Figure 9, left):

Thangka purchased in 21st century China, depicting the White Tara, or bodhisattva of compassion and serenity. The thangka was made specifically for the tourist trade and marketed as very old. The Raman spectrum (Figure 9, right) shows use of phthalocyanine green (633 nm laser for CAMEO reference spectrum, top; 785 nm laser for thangka, bottom spectrum). The XRF spectrum (Figure 10) suggests the use of chrome yellow. Note high manganese (Mn) content due to ‘artificial soot’ on surface: the piece has been artificially aged by darkening with a manganese-based pigment (Figure 10).
Figure 10: Thangka E, XRF spectrum suggesting use of chrome yellow. Note high manganese (Mn) content due to ‘artificial soot’ on surface.

Figure 11: Left: Thangka F. Right: Visible light, backscattered electron imaging, and x-ray map images from a gilded region (green = Au, blue = Ti, and red = Si).
Thangka F (Figure 11, left):

This thangka is modern in both its iconography and origin. Similar to Thangka E, it was purchased on the tourist market in Asia in 2006 as an ‘old’ thangka. A gilded area was examined by visible light, by backscattered electron imaging, and by x-ray mapping (Figure 11, right); the latter technique identified the presence of gold (Au), titanium (Ti) and silicium (Si), which are indicative of modern materials. The FTIR spectrum (Figure 12) showed the use of Prussian blue and phthalocyanine blue synthetic pigments.

![Figure 12: FTIR spectrum of Thangka F showing use of Prussian blue and phthalocyanine blue pigments.](image)

Discussion and Conclusions

Thangkas A, B and C, the 18th and 19th century thangkas, were found to have a traditional Himalayan palette, consisting of vermillion, red lead, and lac dye reds, orpiment (As₂S₃), and iron ochre yellows, malachite, antlerite [Cu₂Cl(OH)₃], and brochantite [Cu₄SO₄(OH)₆] greens, azurite and organic blues (likely indigo), carbon blacks, calcite whites, and grounds of clay, magnesite (MgCO₃), or a mixture of the two.

The mid-20th century Thangka D palette documents the importation of synthetic and Western pigments into the Himalayan region. These pigments include chrome yellow PbCrO₄, artificial ultramarine, and emerald green [Cu(C₂H₃O₂)₂, 3Cu(AsO₂)₂], as well as a barium white ground. They are used in conjunction with more traditional artists’ materials, including vermillion and red lead, magnesite and gypsum.

In Thangkas E and F, the 21st century thangkas, we see the use of the phthalocyanine blue and green pigments, in addition to as yet unidentified synthetic red lake pigments.
While Prussian blue was identified in the previously mentioned study of a 18th-19th century Bonpo thangka\(^5\), it is notable that pigments introduced in the early 19th century in the West do not show up in Himalayan thangkas until the 20th century. However, further analysis of late 19th and early 20th century thangkas is necessary to more precisely determine the date of introduction of these materials. An 1840s account of pigments imported into Nepal and then into Tibet by the British East India Company included lead white, indigo, verdigris and sandalwood.\(^6\)

**Endnotes**


6. Hodgson, Brian Houghton, 1972 (1831). “The Commerce of Nepal”, in book: *Essays on the Languages, Literature, and Religion of Nepal and Tibet: Together with further papers on the Geography, Ethnology, and Commerce of those Countries*. Philo Press: Amsterdam, pp. 91-121. Hodgson was a British East India Company resident of Nepal for nearly two decades. In this paper originally published in 1831, Hodgson used Nepal as the subject and recorded its import and export with special commentary about Tibet. He briefly touched upon the early trade between Newar people of valley of Nepal and India and Tibet and then demonstrated Nepal as a trade center and bridge between British India and Tibet. Notable imported goods from India to Nepal and some of them were further exported into Tibet. Those were fabrics of many kinds, threads, coral, diamond, precious stones (emeralds, rubies, and sapphires), ambers of various kinds, chank,
coweis, gold mohur, golochan, indigo, animal skin of various kinds, saltpeter, brimstone, quicksilver, "singraf” or vermilion cinnabar, “China” and “Country” red lead, ruskappor, camphor, white sandal, Zangar or verdigris, white lead, minerals of various types, hardware, dried fruits, spices, and misc. Hodgson commented that there was a huge demand for opium and indigo from China and Mongolia through Tibet. Tibetan liked English broad cloth for clothing, and purchased some cotton fabric to cover paintings. Hodgson also mentioned another trade route between Russia and China. The Russian imports to China consist of products from Russia, England, and North America; the later two were often in large quantity, usually about half of the imports. Hodgson also noted the direct trade between Nepal and China.

BIOGRAPHIES:

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Jo-Fan Huang is from the Philadelphia Museum of Art.

Xian Zhang and Richard Laursen are from Boston University.

Ann Shaftel is a Fellow of IIC, a Fellow of AIC and a member of CAPC in Canada. She has an M.A. in Asian Art History and and M. S. in Conservation. She has worked preserving thangkas since 1970, including work for major museums worldwide and monasteries in Bhutan, Sikkém, Nepal and Tibetan communities in Northern India, including the Dalai Lama’s museum.


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