SEM-EDX analysis of blue and green pigments used in nineteenth-century China trade paintings

May Chui-in Long | cilong@lcsd.gov.hk

MA Conservation of Fine Art 2014, Northumbria University, Newcastle-upon-Tyne, UK

Introduction

China trade painting, also known as Chinese export painting, is the genre of paintings produced throughout the eighteenth- and nineteenth-century, in the seaport cities in China and Macau (then a Portuguese colony) painted by local artists. These paintings were produced and sold as popular souvenirs to Western merchants and travellers prior to the arrival of photography. China trade painters adapted to Western artistic conventions and easel painting techniques to appeal to the Western market, this could be reflected from the photographic quality of the images they depicted, treatment of perspective, light and shade, as well as the use of a wide range of vivid pigments and colourants.

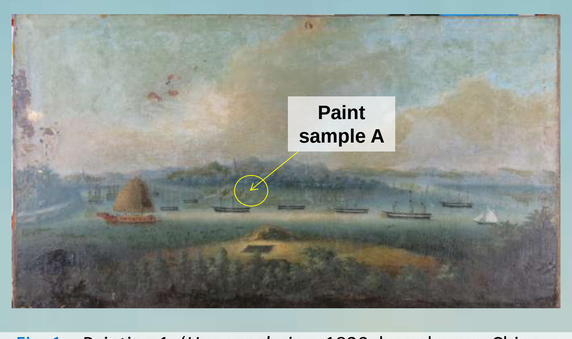


Fig. 1 – Painting 1: '*Huangpo*', circa 1830, by unknown Chinese School artist, (H) 48.0 x (W) 78.5 cm

Fig. 2 – Painting 2: '*View of Hong Kong*', dated 19th-century, by unknown Chinese School artist, (H) 45.0 x (W) 89.0 cm

Fig. 3 – Painting 3: '*Guangzhou New Factories from the Other Side of the River*', circa 1847, by Sunqua, (H) 92.5 x (W) 185.5 cm

Research Aim

To investigate the materials that were used for their construction, in particular identifying the blue and green pigments that were often applied in maritime themed China trade paintings produced in oils. Findings could provide an insight on the common blues and greens in the local painters' palettes and make recommendations for the conservation treatment of these paintings, their long-term storage and display needs.

A selection of three China trade paintings dating from the nineteenth-century from the Hong Kong Museum of Art Collection were identified as suitable candidates for the purpose of this study (Fig.1-3).

Key: Paint sampling location

Methodology & Results

Based on the available resources and schedule for this project, optical microscopy was chosen as the primary pigment identification analytical technique further supported by elemental analysis from Scanning Electron Microscopy – Electron Dispersive X-ray analysis (SEM-EDX). Representative blue / green paint samples were collected from each study painting (Fig. 4-6).

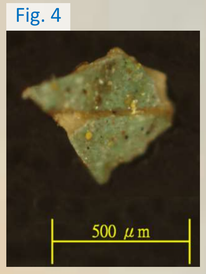
Microscopical Identification of Pigment

Optical microscopy was used to study the Meltmount™ (refractive index, R.I. of 1.662) mounted powder pigments extracted from the respective paint samples. Under a polarizing optical microscope (Olympus BX60) each powder pigment slide was observed in transmitted light and cross-polarized light to study its optical characteristics (Fig. 7-9). Observations were then compared with the characteristics of the potential blue and green pigments that were available in nineteenth-century China.

Collectively for all three powder pigment samples, the bulk of the sample consisted of fine <1µm, rounded particles of a dull grey-green colour, exhibiting optical characteristics of green earth. In various proportions, traces of dark, smeared likely Prussian blue, green with bluish undertone of medium sized ~2-5µm, irregularly shaped, fractured particles of malachite and dark yellow ~4-6µm medium sized, irregularly shaped, fractured particles of orpiment were observed.

Paint sample A

Fig. 4



Paint sample B

Fig. 5

Paint sample C

Fig. 6

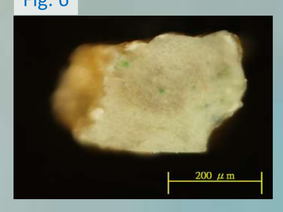


Fig. 7

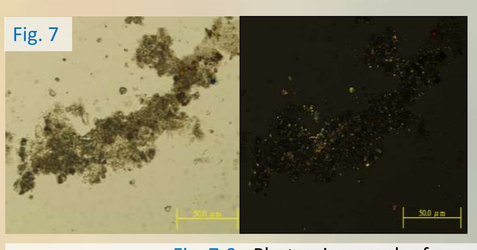


Fig. 8

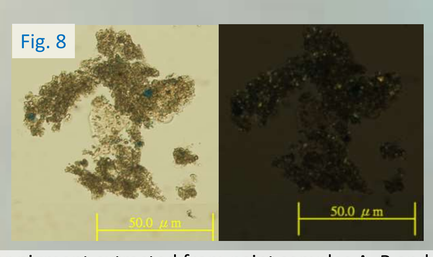


Fig. 9

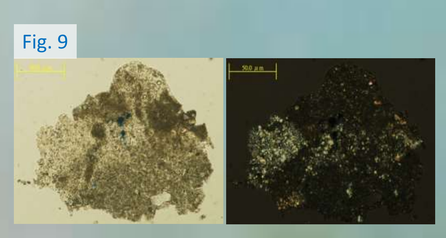


Fig. 7-9 - Photomicrograph of powder pigment extracted from paint samples A, B and C (respectively) in Meltmount™ (L) transmitted light, (R) crossed polars (400x). Consistently the samples contain mostly of the pigment green earth.

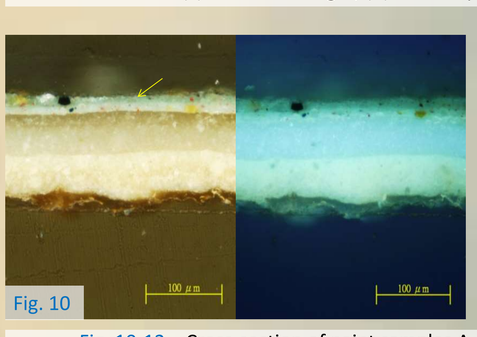


Fig. 10

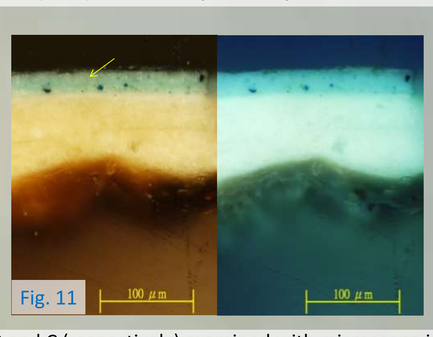


Fig. 11

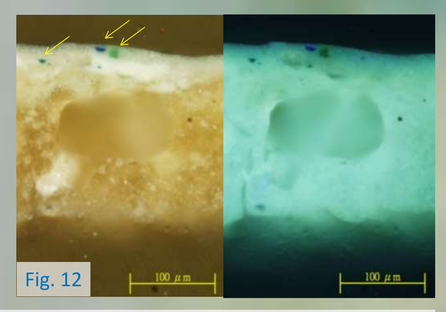


Fig. 12

Fig. 10-12 – Cross-section of paint samples A, B and C (respectively) examined with microscope in (L) reflected light and (R) UV light (200x). Stratigraphic study revealed the paintings were produced in a similar practice, one thin blue-green paint layer over two white ground layers.

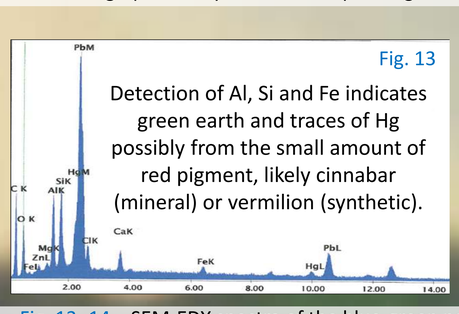


Fig. 13

Detection of Al, Si and Fe indicates green earth and traces of Hg possibly from the small amount of red pigment, likely cinnabar (mineral) or vermilion (synthetic).

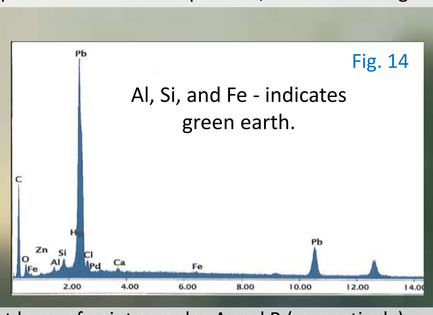


Fig. 14

Al, Si, and Fe - indicates green earth.

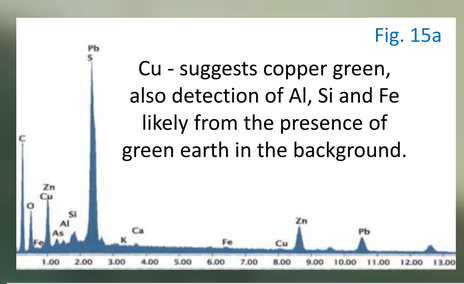


Fig. 15a

Cu - suggests copper green, also detection of Al, Si and Fe likely from the presence of green earth in the background.

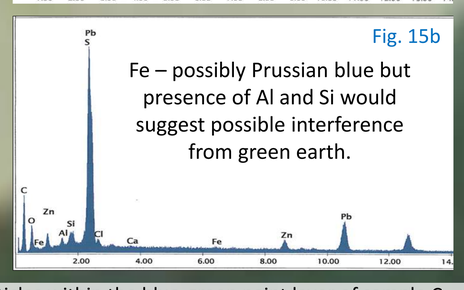


Fig. 15b

Fe – possibly Prussian blue but presence of Al and Si would suggest possible interference from green earth.

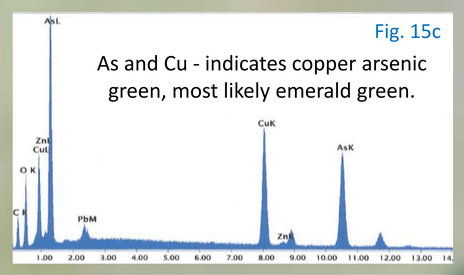


Fig. 15c

As and Cu - indicates copper arsenic green, most likely emerald green.

Fig. 13 -14 – SEM-EDX spectra of the blue-green paint layer of paint samples A and B (respectively), indicated by arrows in Fig.10-11. Traces of Al, Si and Fe are present in both samples.

Fig. 15 – SEM-EDX spectra of individual pigment particles within the blue-green paint layer of sample C, (a) dark green particle, (b) blue particle and (c) green particle, indicated by arrows (left to right) in Fig. 12:.

SEM-EDX spectroscopy

To prepare cross-sections (Fig. 10-12) using the flat-embedding technique (Khandekar, 2003), Bio-Plastic® a polyester-based mounting medium was activated by HY956 catalyst (2% w/w) to set individual paint samples into resin blocks. After polishing, each block was painted with conductive liquid (colloidal) graphite, analysed with SEM (FEI Quanta 200) with EDX, under low vacuum of 100-120 Pa, working distance of 10mm with an electron beam of spot size between 5-6 µm at 30.0kV for EDX.

Elemental analysis from SEM-EDX (Fig. 13-15) showed consistent result with pigment identification from microscopical observations, summarized in (Table 1).

Findings

Results indicate the presence of the following pigments: green earth, malachite, a copper-arsenic green likely emerald green, Prussian blue and orpiment, out of which three are pure greens. It would seem the Chinese artists preferred to work with pure green pigments then adjusting the hue with traces of blues and yellows. This may be an influence from their experience in colour mixing theories from Chinese brush painting techniques (Wang, 1679-1701), further the long tradition of employing various grades (particle sizes) of malachite, which effectively achieved the various dark to light shades of green avoided the need for mixing.

Table 1 – Summary of findings from microscopical identification of pigment and SEM-EDX analysis

Paint Sample	Microscopical ID	SEM-EDX	
	Pigment	Elemental analysis	Pigment
A	green earth, orpiment, dark blue (unidentified)	Al, Si, Fe (green-blue), As (yellow), -	green earth, orpiment -
B	green earth, malachite, Prussian blue	Al, Si, Fe (pale blue) - -	green earth - -
C	malachite, Prussian blue, - green earth	Cu (dark green), Fe (blue), As, Cu (green) -	malachite, Prussian blue, emerald green -

References Khandekar, N. (2003) 'Preparation of cross-sections from easel paintings', *Reviews in Conservation*, 4, pp.52-61. | Wang, G., (1679-1701) The Mustard Seed Garden Manual of Painting. Translated by Mai-mai Sze. Reprint, New York: Princeton University Press, 1978. | Winter, J. (1998) *East Asian Paintings: materials, structure and deterioration mechanisms*. London: Archetype Publications | Yu, F. (1988) *Chinese Painting Colours: Studies of Their Preparation and Application in Traditional and Modern Times*, in Silbergeld, J. and McNair, A. eds. and trans., Hong Kong; Hong Kong University Press

Acknowledgments First and foremost gratitude goes to IIC, granting this opportunity to share findings of this research. Project supervisor, Dr Jane Colburne, Northumbria University to provide inspiration and guidance for this project. Staff at the Conservation Office, LCSD, Hong Kong, Wing-fai Lai and Carol Tang for sharing their analytical expertise, and Albert Lai for his experience working with China trade paintings. Finally, courtesy of the Hong Kong Museum of Art for approving this study and permitting the publication of images from its collection.

Conclusion

Except for malachite the other blues and greens are not commonly associated with traditional Chinese pigments (Winter, 1998). During the nineteenth-century thriving trade between the East and West meant a range of local and imported, natural and synthetic pigments was available to the local artists (Yu, 1988). It is unsurprising then to find foreign pigments in the palettes of Chinese oil painters, due to principle of optics and refractive indices, pigments exhibit differently in oil-based and water-based mediums, so logically Chinese painters would have to adapt to pigments that are suitable for painting in oil.

Future Work

Green earth is a rare pigment to appear on Chinese artworks and artefacts, there is need to verify and potentially identify the source and origin of this green pigment through further archival and scientific research.

IIC 2014 Hong Kong Congress
22-26 September 2014
An Unbroken History: Conserving East Asian Works of Art and Heritage