BRP

BRILL RESEARCH PERSPECTIVES

Colours on East Asian Maps

Their Use and Materiality in China, Japan and Korea between the Mid-17th and Early 20th Century

Map History

BRILL

Diana Lange and Oliver Hahn

Colours on East Asian Maps

Map History

Editor-in-Chief

Carla Lois (*University of Buenos Aires, CONICET*)

Editorial Board

Vera Dorofeeva-Lichtmann (*French National Centre for Scientific Research* (CNRS))
Jordana Dym (*Skidmore College*)
Matthew Edney (*University of Southern Maine*)
Elizabeth Montanez-Sanabria (*Austrian Academy of Sciences*)
André Reyes Novaes (*Rio de Janeiro State University* (UERJ))
Chet Van Duzer (*Stanford University, David Rumsey Map Center*)
Nicolas Verdier (*French National Centre for Scientific Research* (CNRS))

Volumes published in this Brill Research Perspectives title are listed at *brill.com/rpmhs*

Colours on East Asian Maps

Their Use and Materiality in China, Japan and Korea between the Mid-17th and Early 20th Century

By

Diana Lange
Oliver Hahn

BRILL

LEIDEN | BOSTON

This is an open access title distributed under the terms of the CC BY-NC-ND 4.0 license, which permits any non-commercial use, distribution, and reproduction in any medium, provided no alterations are made and the original author(s) and source are credited. Further information and the complete license text can be found at https://creativecommons.org/licenses/by-nc-nd/4.0/

The terms of the CC license apply only to the original material. The use of material from other sources (indicated by a reference) such as diagrams, illustrations, photos and text samples may require further permission from the respective copyright holder.

Library of Congress Control Number: 2022924083

Typeface for the Latin, Greek, and Cyrillic scripts: "Brill". See and download: brill.com/brill-typeface.

ISSN 2589-3955
ISBN 978-90-04-50999-3 (paperback)
ISBN 978-90-04-54562-5 (e-book)

Copyright 2023 by Diana Lange and Oliver Hahn. Published by Koninklijke Brill NV, Leiden, The Netherlands.
Koninklijke Brill NV incorporates the imprints Brill, Brill Nijhoff, Brill Hotei, Brill Schöningh, Brill Fink, Brill mentis, Vandenhoeck & Ruprecht, Böhlau, V&R unipress and Wageningen Academic.
Koninklijke Brill NV reserves the right to protect this publication against unauthorized use.

This book is printed on acid-free paper and produced in a sustainable manner.

Contents

Colours on East Asian Maps

Their Use and Materiality in China, Japan and Korea between the Mid-17th and Early 20th Century

Diana Lange
Humboldt-Universität zu Berlin and Centre for the Study of Manuscript Cultures, Universität Hamburg, Germany
diana.lange@hu-berlin.de

Oliver Hahn
Bundesanstalt für Materialforschung und -prüfung Berlin and Centre for the Study of Manuscript Cultures, Universität Hamburg, Germany
oliver.hahn@bam.de

Abstract

Maps and colours have a close connection. Drawn or printed in black on white, subsequently added colours enhance maps with additional information. Colours were not just there to improve maps aesthetically, but they regulated how they were read and thus reinforced their meanings, significances and ideas. Colour is an important key to a more precise understanding of the map's purposes and uses; moreover, colours are also an important aspect of a map's materiality. The material scientific analysis makes it possible to find out more about the making of colours and the process of colouring maps. By skillfully deploying colours, map colourists were able to create mimetic representations of nature or codify information in an abstract form. The use of colours involved many considerations as to the materials. 'Reading' colours in this way gives a glimpse into the social lives of mapmakers as well as map users and reveals the complexity of the historical and social context in which maps were produced and how the maps were actually made. Within the scope of the three-year joint research project *Coloured Maps* (2018–2021), we undertook an in-depth and systematic study of hand-drawn and hand-coloured maps from East Asia in the Museum am Rothenbaum (MARKK) in Hamburg and produced between the seventeenth and twentieth centuries. With a multi-perspective approach and transdisciplinary methods (humanities and the sciences), we were able to pool and compare the research results from different fields of research on Asian maps. The aim of this publication is to provide a first general overview of the subject of colours on maps in East Asia in the period from the seventeenth to the early twentieth century and to stimulate further research on the topic.

© DIANA LANGE AND OLIVER HAHN, 2023 | DOI:10.1163/9789004545625_002
This is an open access article distributed under the terms of the CC BY-NC-ND 4.0 license.

Keywords

maps and colours – colouring – colourants – dyes and pigments – map production and publishing – non-invasive scientific methods

1 Introduction[1]

Not much has been written about the processes of map colouring in East Asia[2] and on colours on East Asian maps per se. Thus, the search for written sources which exclusively address these topics proved to be very difficult. For example, publications on colour in cartography like the essays of Ulla Ehrensvärd (1987) and Nicolas Verdier and Jean-Marc Besse (2019) refer almost exclusively to map colouring in Europe. The contributions on cartography about China, Japan and Korea in the *History of Cartography* series published by the University of Chicago Press only scratch the surface of the topic of colour.[3] Regarding the scientific analysis of colourants used for map colouring in East Asia, only a few case studies have been undertaken and published so far, such as the investigation of the Bodleian Library's "Selden Map" of China (Kogou et al. 2016). The most striking conclusion is that previous research did not pay attention enough to the people involved in the map colouring process and that the use and meaning of colours and the colouring of maps in East Asia have not been *systematically* examined so far.

Due to the unsatisfactory state of research on colours and colouring in East Asian maps, it has been necessary to broaden the research scope and delve into other related fields. In fact, traditional cartography in East Asia shared many aesthetic principles with painting—the character for 'picture' and 'map' was the same (圖) in Chinese, Korean and Japanese. Furthermore, maps are clearly related to the history of books and printing in East Asia. Thus, the existing literature on more general graphic practices such as painting, writing,

1 The research project *Coloured Maps* (2018–2021) was carried out with the support of the Centre for the Study of Manuscript Cultures and the Mineralogical Museum, Center of Natural History (CeNak), both at the University of Hamburg, the Hanseatic Business Archive Foundation, the Library of Commerce and the Museum am Rothenbaum (MARKK) in Hamburg.

2 As Sivin and Ledyard (1994, 23) suggested in their contribution on East Asian cartography in the *History of Cartography*, the term 'East Asia' is useful mainly as a cultural label, meaning the parts of Asia which have drawn on Chinese institutions, ideologies, and techniques. For the purposes of this book, East Asia involves of China, Korea and Japan.

3 Ledyard 1994, Unno 1994a and Yee 1994a and 1994b.

and printing was a good starting point for the study of mapmaking and map colouring in East Asia.[4] First, the question arose as to whether a colourist or painter would have distinguished between paintings and maps or any other printed illustrations regarding the choice of the materials used. It seems not: the map historian Cordell Yee stated that "it probably wouldn't have occurred to someone making a map to use different pigments than someone who was painting. It is modern scholars who have isolated what we now regard as a distinctive practice from other graphic processes".[5] Consequently our idea was to infer how maps were coloured from how printed illustrations and paintings, in general, were coloured.

Martin Heijdra—a trained Sinologist and Japanologist and Director of the Princeton East Asian Library, who has undertaken extensive research on the history of the East Asian book—noted that "the existing literature shows that hand-colouring of prints is rarely extant in Chinese books."[6] This is probably one of the reasons why the process of colouring and the role of the colourist in China has been neglected in research so far. As Sören Edgren, one of the world's foremost experts on Chinese books and printing stated: "since China did not have a tradition of hand-colouring printed books or printed maps, there was no such artisan role."[7] Indeed, printed maps were often not coloured and manuscript maps, if so, were coloured by non-professional map colourists. According to Tsien, some individuals involved in making maps for woodblock-printed local gazetteers[8] in China are named in the introductory texts of those works. The names of a few cutters of woodblocks appear on the blocks that they carved (Tsien 1985, 266). But most individuals involved in mapmaking in China were anonymous. This is also true for Korea and Japan. Next to the printed maps there exist numerous surviving hand-coloured manuscript maps from East Asia. But also about the producers of these maps little is known. In order to find satisfactory answers to the question of how and by

4 See for example Akin 2021, Brokaw and Reed 2010, and Wu 1936.

5 E-mail correspondence, 8 January 2020.

6 E-mail correspondence, 25 February 2020.

7 E-mail correspondence, 23 February 2020.

8 A gazetteer is "a cumulative record of a territorial unit published in book format, generally by a local government, and arranged by topics such as topography, institutions, populations, taxes, biographies, and literature. Imperial China had nested hierarchies of territorial units and gazetteers." (Dennis 2015, 1) For further and more comprehensive information on the Chinese gazetteer tradition, see Dennis 2015, and the publications and database LoGaRT of the working group *Local Gazetteers* (2013–2023) based at the Max-Planck-Institute for the History of Science in Berlin: https://www.mpiwg-berlin.mpg.de/research/projects/departmentSchaefer_SPC_MS_LocalGazetteers.

whom maps were produced and finally coloured, it was necessary to go back to the actual sources—the maps themselves in all their materiality.

Our goal to carry out research on the meaning and use of colours on East Asian maps, as well as on map colourants and colouring (in particular the use of dyes and pigments) was realizable through close collaboration between the humanities and natural sciences. Based on the study of the colouring of numerous East Asian maps and on publications on collections of such maps kept in different institutions worldwide (such as the British Library, the Library of Congress, the Bibliothèque nationale de France, the National Museum and National Library of Korea, and different institutions in China and Japan) we are now able to provide a first general overview on the use and function of colours on East Asian maps from China, Japan and Korea. The study of different written sources on pigments and dyes in use in East Asia, written reports on material science studies conducted on different maps but primarily our own material analyses undertaken on the collection of East Asian maps kept in the Museum am Rothenbaum in Hamburg[9] and on the collection of Chinese maps at the Max-Planck-Institute for the History of Science (MPIWG) in Berlin[10] allow us to make statements about the origin, compositon, and processing of colourants and their uses according to specific regions.

2 Colour Makes the Map

In East Asia, the regions of China, Korea and Japan have a long tradition of map production. Regarding the content and regions represented on East Asian maps, one can distinguish different scales and thematic genres: world maps, maps of provinces, local administrative maps, city maps, flood control and embankment maps, military maps, maps of famous historical sites, and

9 The East and South-East Asia Collection of the Museum am Rothenbaum includes a collection of East Asian maps from the regions of China, Japan and Korea spanning a period from the seventeenth to the twentieth centuries. A large part of the collection of Korean and Japanese maps is from the Hamburg geologist Carl Christian Gottsche (1855–1909), who acquired the maps at the end of the nineteenth century during his extended stays in East Asia. Maps also found their way into the Museum from journeys of researchers, collectors, merchants and art dealers as well as through collecting trips by Museum's curators. The provenance of a few individual objects is unknown. Among the maps in the Museum am Rothenbaum collection are also numerous colour prints, especially from Japan. Most of the hand-coloured maps are reproduced in Lange 2021.

10 The MPIWG library purchased sixteen Chinese and European maps in the last few years. All these maps were digitized and are accessible online under the collection *Kartensammlungen des MPIWG* ("map collection of the MPIWG"): https://dlc.mpg.de/browse/-/1/-/DC:kartensammlungdesmpiwg/.

route and travel maps. Regarding the mapmaking process, there are planimetric maps, pictorial maps, 'measured maps' drawn to scale, maps with and without grids, and maps with a combination of square grids as well as lines of latitude and longitude (Yee 2008, 1288). Although the cartographic traditions in China, Korea and Japan shared several features, mapmaking and map use present unique characteristics in these regions (Sivin and Ledyard 1994, 23). This also applies to the colouring and the use of colours on maps, although it must be highlighted that before the invention of colour printing, most printed maps in East Asia were usually not coloured by hand but left uncoloured, and manuscript maps were usually made in colour. No specific guidelines for colouring are known from East Asia, although the colouring of maps was treated in a very uniform style. This suggests that it became established at a very early stage—probably before the sixteenth century or, considering the earliest surving maps from China dated 2nd century BCE, even much earlier—and needed no further explanation.

Maps in East Asia were published in various physical formats and in a variety of mediums. The majority were produced on sheets, sometimes bound volumes or atlases, and also as hanging scrolls, handscrolls and folding books. Many Chinese woodblock-printed books included maps, such as local gazetteers (*difangzhi* 地方志). They developed out of the earlier genre of 'map guides' (*tujing* 圖經, *tuji* 圖記 or *tuzhi* 圖志)—collections of maps or illustrations with accompanying explanatory treatises—and replaced them in the Song dynasty in the early 1200s (Dennis 2015, 23f.). During the Edo period (1603–1868), most Japanese maps circulated as portable paper sheets in different formats, such as itinerary maps depicting the roads and sea routes of all Japan (Unno 1994a, 424). Most surviving Korean maps made during the Joseon Dynasty (1392–1897) date from the seventeenth century or later, and are the predominant ones that survived, either as hand-drawn or as wood-block printed, usually bound. Larger maps were usually produced as portable sheets or scrolls (Ledyard 2008, 1311).

Traditional cartographic images produced in East Asia until the nineteenth century shared many aesthetic principles with landscape painting. Chinese, Korean and Japanese maps were often a kind of mixture between a planimetric representation of landscapes, based on measurements during surveys, and landscape drawings or paintings. Thus, it is not surprising that their colouring follows the principles of landscape painting and to find the same colourants generally used in traditional painting applied to these maps (Ledyard 1994, 236). They were used to display hills and mountains, groups of trees, cliffs and bays, rivers and oceans by using realistic conventions. On many of these pictorial maps, small slips of coloured paper (often yellow or red) of different sizes including additional information were glued on the maps' surface.

2.1 *Colour Systems of East Asian Maps*

The first step in studying the use of colour on a map is to examine the *colour system*; that is, to look at *what part* of the map's content was selected to be coloured. In this respect, we distinguish among full-colouring, spot-colouring, or non-colouring.[11]

East Asian maps were widely coloured according to a broadly similar system up to the nineteenth century. On most Chinese, Korean and Japanese maps, water bodies are tinted in some way and the land is left unpainted, although some topographical elements might be picked out in colour (see Fig. 1).

The opposite situation, namely full-colouring applied to the land and the oceans being left uncoloured, started in East Asia in the late seventeenth century. This colour system was primarily used to distinguish the individual administrative units, such as Chinese or Japanese provinces, as was done on the European maps for different countries. Even though China, Japan and Korea did not accept many new European ideas and preferred to create maps maintaining their own visual traditions during the eighteenth and nineteenth centuries,[12] the outward appearance—the style of colouring and use of colours of the maps in East Asia—changed step by step towards a more European style—particularly in the second half of the nineteenth century. The adaption of this European-influenced colour system started in Japan in the late seventeenth century. The earliest full colouring of provinces of Japan can be found for instance on the woodblock printed hand-coloured 1686 *Honchō zukan kōmoku* 本朝圖鑑綱目 ("Outline map of our country") and the 1691 *Nihon kaizan chōrikuzu* 日本海山潮陸圖 ("Map of sea, mountain, tide and land of Japan") by Ishikawa Ryūsen 石川流宣.[13] There also exist maps on which land and sea are both fully coloured, such as the manuscript map *Keichō Nihon sōzu* 慶長日本総図 ("General map of Japan of the Keichō era"),[14] the manuscript maps *Daming di li zhi tu* 大明地理之圖 ("Map of the territory of the Ming Dynasty") made by Murayama Koshu 村山光衆 in 1762,[15] and the woodblock

11 See also Lange 2022, 121.

12 See also Pegg 2014, 12.

13 See https://open.library.ubc.ca/collections/tokugawa/items/1.0167734 and https://open.library.ubc.ca/collections/tokugawa/items/1.0213158. For further information on Ishikawa Ryūsen and his map style, see Yonemoto 2016.

14 This map was made in the early Edo period and is held by the National Diet Library Toyko (Call Number WA46-1), and a high-resolution image of the map is available at http://dl.ndl.go.jp/info:ndljp/pid/1286203?__lang=en.

15 This map is held in the Musée Guimet (https://pt-br.facebook.com/museeguimet/photos/carte-géographique-monumentale-de-lempire-chinois-au-temps-des-ming-chinois-au-t/10156613824694265/) and was published in Singaravélou and Argounès 2018: 61, no shelfmark. The title on the maps reads *Daming di li zhi tu* 大明地理之圖; however, it is cited as *Ming chao di li zhi tu* by Musée Guimet.

FIGURE 1 Early eighteenth-century Korean manuscript map of Jeolla province 全羅道 showing the typical colour system of this period: the sea and the rivers being coloured in full while the land remains uncoloured. 105 × 63 cm.
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. XX SOAS 718

printed and hand-coloured Japanese world map *Bankoku ichiran zu* 萬國一覽圖 ("Visualized map of all nations") made by Koyano Yoshiharu 古屋野意春 in 1809 and 1810.[16] The full colouring of land areas to distinguish administrative units did not appear in China before the eighteenth century, such as on the late eighteenth-century woodblock printed and hand-coloured *Jing bian tian wen quan tu* 京板天文全圖 ("Complete map of astronomy and the Qing Empire") by Ma Junliang 馬俊良 kept in the Bibliothèque nationale de France.[17] In nineteenth-century maps, colours also separated the *tianxia* 天下 genre of maps which depict "All under Heaven", focusing on Qing China (1644–1911) as the centre and displacing the 'outside world' to the periphery. Unlike the Chinese provinces, the surrounding countries were not displayed in colour on such maps.[18] While on eighteenth-century city maps of Beijing the different quarters of the city were distinguished by the different colouring of the streets (using only three colours: light pink, yellow and blue),[19] the quarters were fully coloured on later nineteenth-century city maps, giving to the city the aspect of a consolidated unity. Some eighteenth- and nineteenth-century maps show land areas fully coloured—such as the Chinese provinces—surrounded by uncoloured regions, while the sea was fully coloured in yellow.[20] In Korea, the full colouring of land areas to distinguish administrative units did not appear before the nineteenth century.[21]

16 There is a copy of the map at the University of British Columbia (G3200.1809 K6; G3200_1809_K6); a digital image of the map is available at https://open.library.ubc.ca/collections/tokugawa/items/1.0227921. Another version from a Private Collection with a different colouring was published in Singaravélou and Argounès 2018: 38–39.

17 Département Cartes et plans, shelfmark: GE A-1871, see https://catalogue.bnf.fr/ark:/12148/cb443727906. For a later example see two maps at the Library of Congress: the late nineteenth-century woodblock printed and hand-coloured *Guangdong quan sheng shuilu yu tu* 廣東全省水陸輿圖 ("Map of the waterways and roads in Guangdong Province") https://www.loc.gov/item/gm71005159/ (call number G7823.G8 1887 .L5 Vault) and the manuscript map *Zhili yu ditu ce* 直隸輿地圖冊("Atlas of Zhili province") made in 1859, https://lccn.loc.gov/2002626783 (call number https://lccn.loc.gov/2002626739).

18 For a detailed account of the visual representation of China on *tianxia* maps see Pflug 2019.

19 See for example the manuscript map *Beijing neicheng tu* 北京內城圖 ("Urban Plan of the City of Beijing"), made 1747–1774, kept in the British Library (Add. Ms. 19577), published in Xie and Lin 2015: 76–77.

20 See for example the eighteenth-century woodblock printed and hand-coloured *Daqing wannian yitong tianxia quan tu* 大清萬年一統天下全圖 kept in the Bibliothèque nationale de France, département Cartes et plans, GE C-5353 (1–3 RES), see http://catalogue.bnf.fr/ark:/12148/cb40746333r and the hand-coloured woodblock print *Daqing yitong tianxia quan tu* 大清一统天下全图 ("Great China Embracing the Kingdoms under Heaven") [1818] kept in the Library of Congress: https://lccn.loc.gov/2021668267, LOC control number: 2021668267.

21 This statement is based on the study of numerous East Asian maps kept in the Museum am Rothenbaum in Hamburg and on publications on collections of such maps kept

2.2 *Colour Schemes of East Asian Maps*

The most common term used in connection with map colouring is the *colour scheme*, which can be defined as a particular arrangement or combination of colours.[22]

As already mentioned above, traditional East Asian maps share many aesthetic principles with landscape painting. Thus, it is not surprising to find similar colour schemes on maps and paintings and that the colouring of topographical features on maps is related to their naturalistic appearance. Mountains are brown or green, but in some cases, they are blue (similarly as they appeared in many Chinese landscape paintings of the time). Seas and rivers are green or blue, although occasionally muddy streams and stretches of rivers are given a brownish or reddish tone.[23] The Yellow River in China, however, is usually painted yellow on Chinese, but also on Korean and Japanese maps of China (see Fig. 2).[24]

The use of colours played a significant role on river and embankment maps where different colours were used to distinguish different waterways and streams—such as the Grand Canal and its tributaries. Bank reinforcements and dykes were also marked by colours. Lock gates, bridges and lakes which served as overflow basins for floodwaters, were usually marked on such maps by pictorial (coloured) signs (see Fig. 3).

On many East Asian maps, in particular from the seventeenth century onwards, we find similar colours used for the same purposes: red was used for cities, military-related features, roads, and some settlements. On some maps, roads and sea routes were also tinted in yellow. Borders were coloured in various colours such as green, red or yellow, and sometimes also left uncoloured. Other features and lettering were usually drawn in black.

Other colour schemes provided information about the cultural and administrative units within the various regions. The classical Chinese *wuxing* 五行 or 'five phases system' played an important role in this context, in particular on Korean maps. According to this system, the centre is yellow, the East is green or blue, the South is red, the West is white, and the North is black (see Fig. 4). The

in different institutions worldwide, see for example Han'guk Kojidojip P'yŏnch'an Wiwŏnhoe 2012, Jang et al. 2018, Lin and Zhang 2013, Wigen, Sugimoto and Karacas 2016, Xie and Chen 2018, Xie and Lin 2015.

22 See also Lange 2022, 121.

23 For example, on the *Mukden-I dedun uden-I-nirugan* ("Imperial Ancestral Grave Visit Map"), a route book of an imperial tour between Beijing to the Qing imperial ancestral graves, dated 1778 (MacLean Collection Chicago, no shelfmark) a dried-up riverbed is tinted in reddish-brown (Pegg 2014, 33).

24 See for example the *Map of China and Neighboring Countries* in the National Museum of Korea: M 138, Joseon Dynasty] https://www.museum.go.kr/site/eng/relic/search/view?relicId=2506.

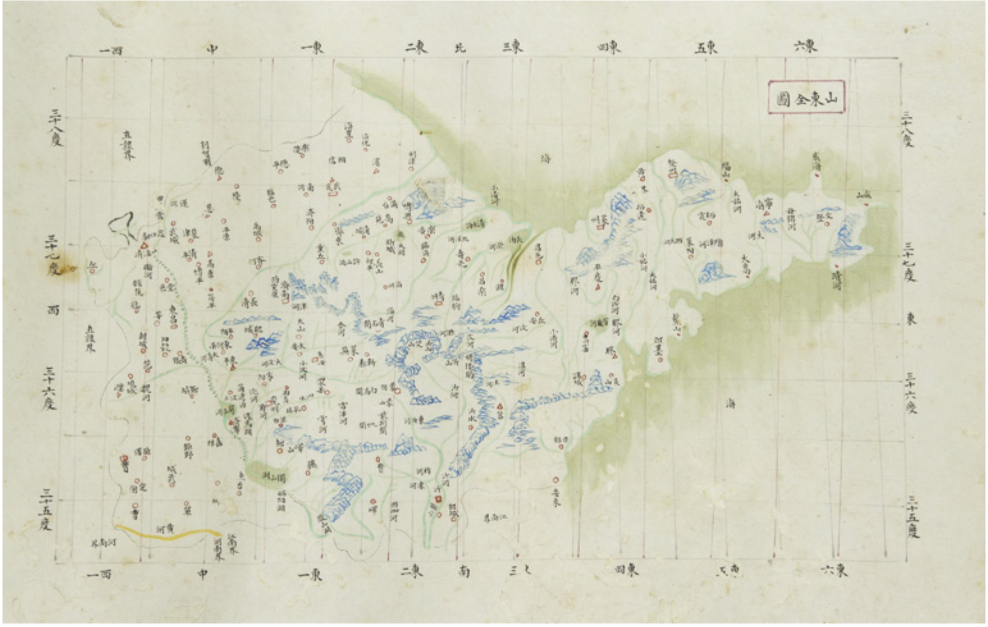


FIGURE 2 Extract from an eighteenth-century Chinese map scroll entitled *Tianxia yutu*, showing Shandong province. The colour scheme commonly found on East Asian maps has been used here: the ocean and the rivers are green (except for the Yellow River, which is shown in yellow in the lower left corner); mountains and mountain ranges are blue. 60 × 1500 cm (entire scroll).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. 640:07

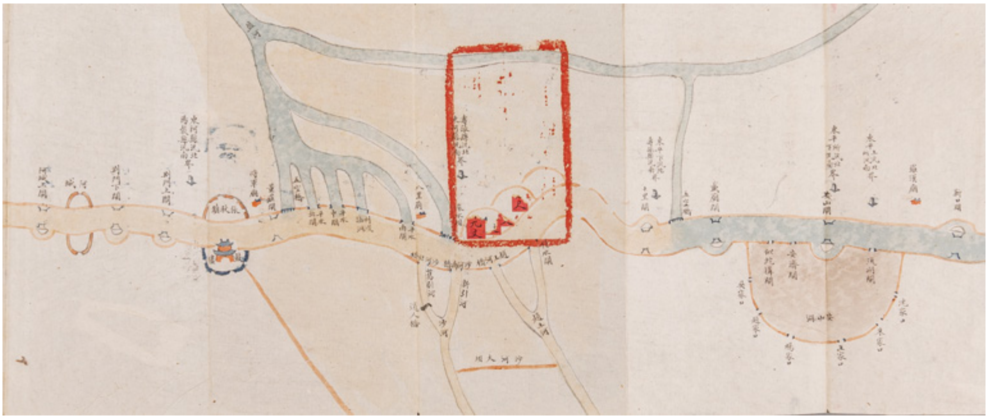


FIGURE 3 Detail of *Puhe ting Guangxu ershiliu nian suixiu gongcheng ti gu tu* 捕河廳光緒貳拾陸年歲修工程題估圖 (“The Grand Canal embankment repair map for the sub-prefecture Puhe, in the year Guangxu 26 [1900]”). 19 × 77 cm (entire map).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. 32.175:2341

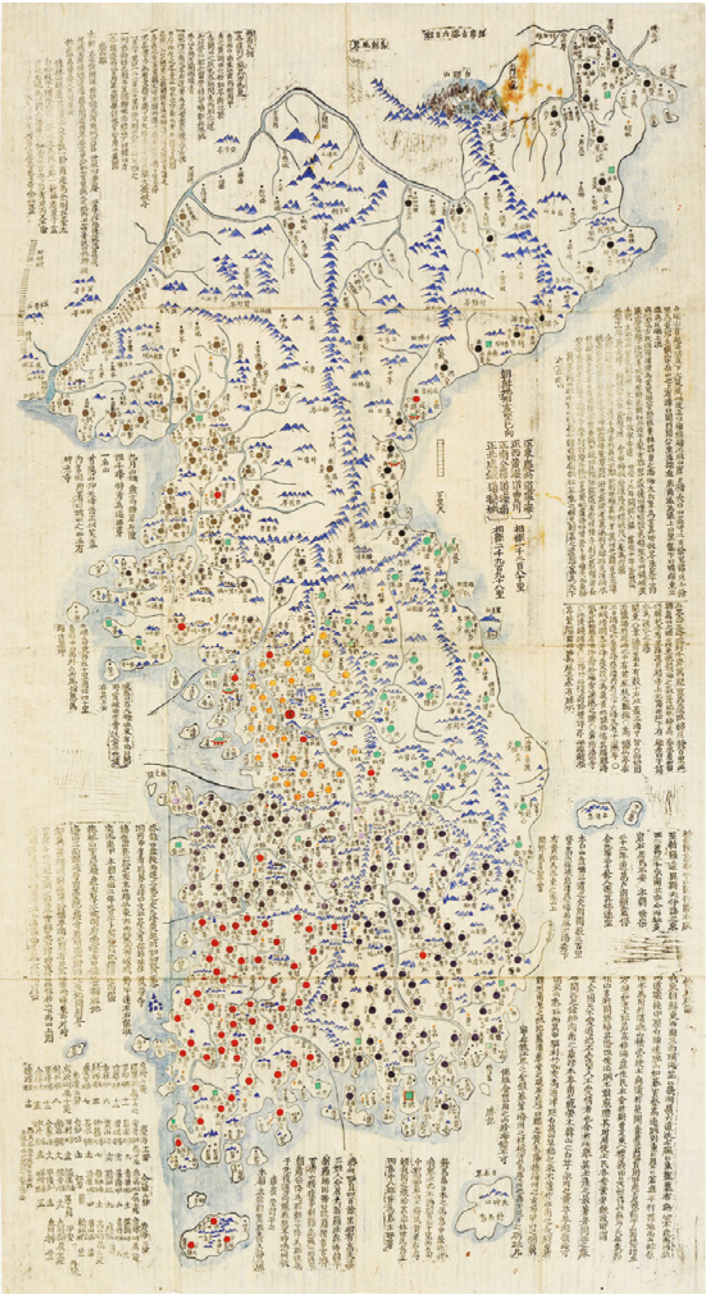


FIGURE 4 Map of Korea, Dori-pyo 道里標 ("Tables showing the miles between provinces"). Hand-coloured woodblock print, *c.*1820, coloured according the colour scheme based on the *wuxing* system. 103 × 58 cm.
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 12.24:39

colours chosen to distinguish the provinces often correspond to this scheme. Provinces located in the intercardinal directions are often tinted with a mix of the colours of the two neighbouring cardinal directions. However, the provinces do not have clear borders and are not fully coloured but represented by overlapped circles. The names of the district magistracies belonging to the different provinces are written within, or next to, the relevant circle.[25] This colour scheme, with occasional variations, is a common though not a universal feature of coloured administrative maps made in Korea up to the nineteenth century. The colouring of the frames surrounding the indication of the cardinal directions on Japanese maps also often follows the *wuxing* scheme. In some cases the characters indicating the cardinal directions are written in dots which are completely coloured in the respective direction colours 東 *dong* (blue/east), 北 *bei* (black/north), 南 *nan* (red/south) and 西 *xi* (white/west).[26]

2.3 *Colour Codes of East Asian Maps*

The colour code of a map defines the range of colours selected to convey specific information about the places and features represented on a map. In this sense, the colour code of a map is part of the map's colour scheme: the colour scheme refers to the choice of specific colours for the different elements of the map, while the colour code defines and conveys these colours.[27]

On many East Asian maps, the cultural and administrative function of pre-eminent places was emphasized or 'coded' through the use of a geometric outline, such as a square, rectangle, triangle or circle, to mark the location. The shape might then be infilled with colour, in which case the place name was written immediately next to it; otherwise, the name was written inside the outline. By imaginatively combining different shapes and colours for outline and infill, mapmakers were able to communicate a considerable range of information through their coding of the place sign. Not all place signs had to be abstract, though, and some functions are indicated pictorially. Houses, temples and walled enclosures, for instance, are illustrated in naturalistic or schematic style and may be coloured in different colours.

The additional application of colours to the geometric outlines played different roles in the different regions. On Chinese maps, place names were often encoded using specific (coloured and uncoloured) shapes to offer information about the size and configuration of local government structures: for example, squares often stood for prefectures, triangles for sub-prefectures and circles represented districts. In Japan, fewer visual codes were used, and these were

---

25 See also Ledyard 1994, 282, 291f., and 309 n.220.

26 See for instance the manuscript map of Naniwa Port, Osaka (dated 1799 and kept in the University of Tsukuba Library), published in Uesugi 2016b, 71.

27 See also Lange 2022, 123.

FIGURE 5 Map from a late eighteenth-century Korean manuscript hand atlas, showing a detail from Gyeongsang province 慶尙道 in southeastern Korea. Variously coloured frames and cartouches of different shapes were used to code information about places on this map. 22,5 × 35,8 cm (entire map). © MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 82.93:1

based on a system of shapes and colours corresponding to the various administrative units: for example, red rectangles with a black border were often used to represent the names of territories, yellow rectangles with red borders for castle towns, red-bordered ovals for military stations, small black open boxes for old castles and battlefields, and small black circles for hot springs. Korean mapmakers developed an even more complex combination of text and image to demarcate different administrative bodies: coloured circles (or other shapes such as squares or triangles) were used for administrative units, with name, type and the largest place name often written inside the circle. The district status was indicated immediately next to the dot or cartouche (see Fig. 5). Strongly simplified, it can be said: administrative information on Chinese maps was coded by different shapes, on Japanese maps it was a combination of colour and shape, and on Korean it was presented by coloured shapes with differences provided primarily through texts (Pegg 2014, 10).

3 Colour Meets Map

The production and colouring of maps in East Asia have gone through different phases, in particular from the seventeenth century onwards. While publishing houses played a significant role in the development of the colouring of European maps,[28] the colouring of maps in East Asia experienced fewer changes over that period—at least compared to what happened in Europe. Although it is not yet clear when exactly colours were used with a functional purpose (and not only as a decorative addition) on Chinese, Korean and Japanese maps, the use of colours (and signs) on maps in East Asia was standardized at an early date. The most significant changes to map-making traditions in East Asia and the colouring of these maps occurred from the sixteenth century onwards with two developments: (1) the introduction of European maps in the sixteenth and seventeenth centuries by Jesuit missionaries, and (2) the import of artificial colourants and their recipes (such as Prussian Blue) from Europe from the eighteenth century onwards. China, Korea and Japan responded to European cartography in different ways: European mapping seems to have been adopted more quickly in Japan than in China, and less quickly in Korea (Yee 1994a, 229–30). Nevertheless, during the eighteenth and nineteenth centuries, all three regions resisted many new European cartographic conceptions and visual styles and preferred to create maps maintaining their own visual traditions.[29] However, in the second half of the nineteenth century, the appearance of the maps in East Asia changed step by step towards a more European style—including the style of colouring and use of colours.

3.1 *Colours on Chinese Maps*

China has a very rich tradition of mapmaking which includes a great variety of maps. Tens of thousands of maps were produced by various government departments, local governments, and also by private scholars in the course of the past 2,000 years (Cao et al. 1994).[30] The tradition of using different colours in map production took shape relatively early in China: three of the oldest existing Chinese maps drawn in different colours were found in a tomb dating from the 2nd century BCE at Mawangdui, in today's Hunan Province, in the 1970s. These maps were drawn on silk with organic colours. One of these three maps is the *Zhujun tu* 駐軍圖 ("Garrison map") showing the Dashen River Basin in the upper reaches of today's Xiaoshui River in Hunan Province where black lines represent mountain ranges, green/light brown lines signify

28 For a detailed discussion of this issue, see van der Linde 2020 and Lange and van der Linde 2021.

29 See also Pegg 2014, 12.

30 These maps are rare and very scattered, but more than 600 selected items were compiled and published in three Chinese volumes in the 1990s, each entitled *Zhongguo gudai ditu ji* 中国古代地图集 or *An Atlas of Ancient Maps in China*, covering three historical periods: from the Warring States Period to the Yuan Dynasty (476 BC–AD 1368), the Ming dynasty (1368–1644), and the Qing dynasty (1644–1911) (Cao et al. 1990, 1994 and 1997).

rivers, red dotted lines roads, red triangles beacon-fire spots, red lines administrative boundaries, black circles villages, and black circles framed in red stationed troops and bases for ordnance and supply depots.[31] According to Yan the *Zhujun tu* is "the earliest coloured map as well as the earliest military map found so far in the world" (1998, 26).

Unfortunately, not many early maps prepared in colour survived. For example, the cartographer Pei Ju 裴矩 (547–627), who travelled to Central Asia as an official envoy, produced the *Xiyu tuji* 西域圖記 or "Maps of and Notes about the Western Regions". The work is lost except for its preface which is included in his biography in the *Suishu* 隋書 ("History of the Sui"). It is said that on these maps Pei depicted the costumes and physical features of the kings and the subjects the "Western regions" in colour.[32]

On most of the surviving Chinese manuscript maps from the fourteenth to sixteenth centuries, a combination of signs and colours was used to represent different geographical elements. For instance, on the *Da Ming hun yi tu* 大明混一圖 ("Amalgamated map of the Great Ming Empire"),[33] drawn in colours on silk around 1389, no distinct boundary lines are shown, only different colours of the square frames for place names are used to distinguish China from other countries. The seats of prefectures, districts and counties subordinate to the highest administrative departments are indicated by pink rectangles. The names of the central and imperial capitals are written in red and the cities themselves are indicated by blue squares. Mountains and rivers are depicted in the style of traditional Chinese painting, that is, mountain ranges are portrayed in green, and the position of selected important mountains is marked in pink rectangles. Some are painted in white to suggest perennial snow. Waterways are shown in greyish-green lines with exception of the Yellow River, which is shown in yellow. The oceans are coloured dark green.

The mapmaker Yang Ziqi 杨子器 (1458–1513) used over twenty coloured octagonal, circular, square, rhombic or rectangular framed signs on his *Yang Ziqi ba yu ditu* 杨子器跋舆地圖 ("Map [of China] with a postscript by Yang Ziqi"),[34] a map of the administrative divisions of the whole nation originally

31 Chang 1979, 12, Cao et al. 1990, 18, and Yee 1994b, 41.

32 Wu 1940, 41–42 and Park 2015, 125.

33 https://z,.wikipedia.org/wiki/大明混一图, a copy is illustrated in Cao et al. 1994, 34–35. The map is stored in the First Historical Archives of China (*Zhongguo di yi lishi dang an guan* 中国第一历史档案馆) in Beijing, no shelfmark.

34 https://www.newton.com.tw/wiki/楊子器跋輿地圖, a copy is published in Cao et al. 1994, 40–41, in Hu 2000: 179–81 and in Yan et al. 1998: 96–97. For further information on this map see Cao et al. 1994, appendix, 22.

drawn on silk in 1512–1513.[35] He used red for the border lines of the provinces, the mountains are painted green, the Yellow River yellow. Cities and towns are white circles and provincial capitals are red circles. The two capitals (today's Beijing 北京 and Nanjing 南京) are represented as yellow octagons with red borders (Hu 2000, 49). There is no explanatory legend provided for the different signs used to indicate places; instead of this, they are described in words in the "Guide to the use of the Map." (Yan et al. 1998, 96).

On the anonymous manuscript map *Huai'an fu tu* 淮安府圖 ("Map of Huai'an Prefecture"), made in 1589, seats of prefectures, districts and counties are shown by signs in the shape of grey-coloured city walls, while temples and monasteries are mostly depicted as red buildings.[36] The maps in the 1577 manuscript encyclopedia *Gujin tushu bian* 古今圖書编 ("Complete collection of pictures and books of ancient and modern times") were drawn in four colours: black was used to delineate the shape of the mountains, applications of green can be found on the mountains, rivers and the ocean are also tinted in green. The outlines of cities are traced in black with orange to decorate their walls. Blue was used for the outer frame of the maps. Orange was also used for drawing the boundaries.[37] On the 1590 river protection map *Hefang yi lan tu* 河防一籃圖, drawn on a scroll of stiff silk by Pan Jixun 潘季馴 (1521–1595), the Yellow River is shown in yellow, while the Grand Canal is represented in green. The upper part of mountains and outlines of cities are coloured blue while the lower part of mountains is coloured green.[38]

The practice of using a combination of signs and colours to represent different elements on maps also continued on Chinese maps from the seventeenth century onwards. For example, on the *Wang Pan ti shi yu ditu mo hui zengbu ben* 王泮題識輿地圖摹繪增補本 ("Supplementary copy of Wang Pan's inscription map") painted in colour between 1603 and 1626 by the prefect Wang Pan 王泮, more than twenty different signs were used to distinguish the identities

35 See Yan et al. 1998, 96. The original map is lost, but a reproduction was made in 1526, now kept in the Lushun Museum in Liaoning, China.

36 This map is published in Cao et al. 1994, 46, the map is kept now in the National Library of China (*Zhongguo guojia tushuguan* 中國國家圖書館) in Beijing. No shelfmark.

37 Copies of four maps are published in Cao et al. 1994, 50–52, further information can be found in the appendix: 23. According to Cao et al. 1994 (appendix, 23), a colour transcript of the encyclopedia is kept in the National Library in Beijing (*Zhongguo guojia tushuguan* 中國國家圖書館), no shelfmark.

38 A copy is illustrated in Cao et al. 1994, 53–55; for further information see Cao et al. 1994, 23–24 (appendix). According to Cao et al. 1994 (appendix, 24) the map is at the Chinese Historical Museum in Beijing, no shelfmark.

of over 5,000 place names.[39] All seas were coloured green, while cartouches in different colours were used to distinguish the different provinces.[40] In the manuscript *Yunnan fu tu* 云南府圖 ("Map of Yunnan Province"), an atlas containing 21 maps made between 1682 and 1698, boundaries and administrative divisions are represented by black lines, while roads are shown as red lines. Rivers and lakes are coloured green, mountains blue, brown, green or white. On the *Peng tai hai tu* 澎台海圖 ("Map of the Penghu Islands and Taiwan"), a scroll map made around 1730, lines of communication are shown as red dotted lines and sea routes are represented in dark green. On the 1692 manuscript map *Zhili tu* 真隸圖 ("Map of Zhili"), single curved lines in red, yellow, blue, green, black, and white are made use of on the map to distinguish between the boundaries of different prefectures. The capital cities or towns of prefectures, districts and counties are all depicted in green or brown with gates of varying sizes.[41] Military maps, such as for example on the anonymous early nineteenth-century manuscript map *Wangjiangxian ditu* 望江縣地圖 ("Map of Wangjiang County"), often illustrate the military installations and troop deployment of a region. In this context, the troops belonging to different military units are represented in different colours: the *xi bing* 西兵 or "western soldiers" by white flags and the *dong bing* 東兵 or "eastern soldiers" by red flags.[42]

Most of the examined maps are not provided with legends for the different (coloured) signs. As Alexander Akin holds, "in premodern and early modern Chinese works the signs used on maps for mountains, town walls, bridges and other features are generally treated as self-explanatory; it was unusual to provide a key to standardized symbols" (2019, 53). Thus, we can assume that the use of signs on maps was so standardized that no key was necessary and thus it was rather unusual to provide a legend for such signs. The first legend in the history of Chinese map making is said to be used by Luo Hongxian 羅洪先 (1504–1564), for the production of his famous woodblock-printed *Guangyu tu*

39 The original map is lost, it was made between 1569 and 1575 by an anonymous author (see Huang 2013, 132). In 1594 it was copied by Wang Pan (Bibliothèque nationale de France, département Cartes et plans, shelfmark GE A-1120 (RES), see https://gallica.bnf.fr/ark:/12148/btv1b52504834s) and by Korean cartographers. For further information on this map see Xie and Chen 2018, 12–14 and Cao et al. 1994, 66–67.

40 Cao et al. 1994, 29 (appendix).

41 Published in Cao et al. 1997, 40–44. According to Cao at al. 1997 (appendix, 24–26), these maps are held respectively in the Library of the Chinese Academy of Science *Zhongguo kexueyuan wenxian qingbao zhongxin* 中国科学院文献情报中心 in Beijing, in the Lushun Museum in Dalian and the First Historical Archives of China *Zhongguo di yi lishi dang an guan* 中国第一历史档案馆 in Beijing.

42 See Ting 1997, 68–69 and 73. The map makes part of the collection Tam Siu Cheung, Hongkong.

廣與圖 (“Enlargement of the Terrestrial Map”). All the twenty-four standardized symbols used on this map are listed in legend form.[43]

Colours also played an important role in Chinese map production to depict information from the past on contemporary maps. For example, the Chinese cartographer Jia Dan 贾躭 (730–805) used red and black to distinguish contemporary place names from historical place names on his manuscript maps, and this criteria was even adopted on later maps, such as on the *Jingu yu ditu* 今古與地圖, including the earliest historical atlas printed, also in red and black.[44] This atlas was made in 1638 by Wu Guofu 吳國輔 who used black ink for Ming dynasty (1368–1644) names and red ink for the names of ancient prefectures and administrative districts.[45] The drawing of the ‘historical’ and ‘modern’ lines with red and black seems to correspond to the Chinese tradition of marking the historical chronology of the constellations on celestial maps in different colours. When Chinese astrologers started depicting the sky in the fourth century BCE, they at first used different colours to distinguish the constellations of the three different schools of the astrologers Shi Shen 石申 (red), Gan De 甘德 (black), and Wu Xian 巫咸 (white, open circles).[46] The use of red and black is also found on later terrestrial maps during the Qing Dynasty to distinguish different grid systems. For example, on a Chinese scroll map entitled *Tianxia yutu* 天下輿圖 kept at the MARKK in Hamburg—which most probably was made in the eighteenth century—the Chinese grid was drawn in red and the system of longitude and latitude in black (see case studies, in Section 6). In contrast to this, on the nineteenth-century *Huangchao yitong yu di quan tu* 皇朝壹统與地

43 Yan et al. 1998, 102.

44 Jia Dan prepared historical atlases showing the boundaries of states in colour and the large map of the Eastern regions entitled *Hai guo hua yi tu* 海國華夷圖 and the *Gu jin jun guo xian das si yi shu* 古今郡國縣道四夷圖. None of these maps has survived, but it is said that red and black colour was used to distinguish ancient and contemporary place names (Wu 1940, 42). For an exemplar of the *Jingu yu ditu* kept in the Library of Congress (shelfmark B182.078.W95) see: https://www.loc.gov/item/2002530058. Another exemplar is kept in the China National Library in Beijing *Zhongguo guojia tushuguan* 中国国家图书馆 (former Beijing Library *Beijing tushuguan* 北京图书馆) (no shelfmark), reproduced in Yan et al.1998, 153.

45 Cao et al. 1994, 29 (appendix). For the use of the colours black and red to distinguish ancient and contemporary places see also Wu 1940, 42. The system of using black and red colours to distinguish contemporary and ancient features was still used in the twentieth century, see for example the “Map of the Yellow River Mouth” in the *Shui jing zhu tu* 水经注图 (“Atlas of Ancient Waterways”), printed in 1905 and published in Yan et al. 1998, 256–57. China National Library in Beijing *Zhongguo guojia tushuguan* 中国国家图书馆, no shelfmark.

46 See Stephenson 1994, 530–532. See for example the eighth-century *Dunhuang xing tu* 敦煌星圖 (“Dunhuang Celestrial Map”) in Yan et al. 1998, 36–37. British Museum, no shelfmark.

全圖 ("Complete Map of the Unified Qing Empire") the Chinese square grid was printed in black and the system of longitude and latitude in red.[47]

Numerous maps depicting China also include the names of the nine historical provinces from the book *Yugong* 禹貢 ("Tributes of Yu", a part of the Chinese classic *Shujing* 書經, the "Book of Documents"). Yu was a mythical Emperor of China who rose to fame principally by warding off large-scale floods, and who originally divided the country into these nine regions. They are often represented by nine squares with coloured outlines (often red) containing their names. Besides these, other signs such as red-outlined circles were used to denote locations of historical significance—such as, for instance, the birthplace of the philosopher Confucius (551–479 BC), see for example the map in Fig. 6. Mapmakers who produced such maps did not intend to reflect the 'real' China of the time when the maps were made, but rather to show China at a past time, such as the era of the Chinese Classics, in other words before the second century BCE. Up to the mid-nineteenth century, many Korean maps show the administrative organization of the Chinese Ming Dynasty (1368–1644) and a cultural panorama of Chinese civilization reaching back to ancient days.

FIGURE 6 Detail of a representation of China on an untitled nineteenth-century Korean world map. The squares outlined in red give the names and additional information about the central Chinese provinces. The smallest red-outlined squares contain the names of the nine historical provinces from the book *Yugong*, and red-outlined circles mark locations of historical significance. 74,5 × 71,4 cm (entire map).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 12.24:46

47 https://www.crouchrarebooks.com/maps/longitude-and-latitude-on-a-map-of-the-qing-empire. A print of this map kept in the China National Library in Beijing *Zhongguo guojia tushuguan* 中国国家图书馆 (no shelfmark) is reproduced in Yan et al. 1998, 230–31.

Despite the many colourful maps that have survived, it can be said that printed maps were rarely hand-coloured in China. This opinion is also shared by Martin Heijdra who stated: “I have certainly seen many books on historic maps, and Chinese printed maps with colored areas within China are just very rare indeed.”[48]

3.2 *Colours on Japanese Maps*

Most of the surviving Japanese maps date from the Edo period (1603–1868), and Japanese cartography before the mid-nineteenth century was characterized by diversity.[49] The Japanese produced city maps, province, national and world maps, local maps of manors, maps of the estates of religious institutions, marine charts and route maps as well as maps from Buddhist cosmology (Unno 1994a, 346). The representation of the environment in pre-modern and early-modern Japanese cartography follows an iconic code, which includes lines (to represent mountains, roads, and rivers) and icons but also coloured surfaces. Signs on such maps are “often pictorial but usually standardized enough to work as icons” (Berry 2006, 61). In contrast to Chinese and Korean maps, it was not unusual to provide a legend for standardized signs on Japanese maps, in particular on eighteenth- and nineteenth-century printed maps. Legends that provide the key exclusively for the colours used on maps are also only to be found on Japanese maps (Figs. 7 and 8). One possible explanation for the common use of legends on Japanese maps is the earlier influence of European cartography—where legends were often used.

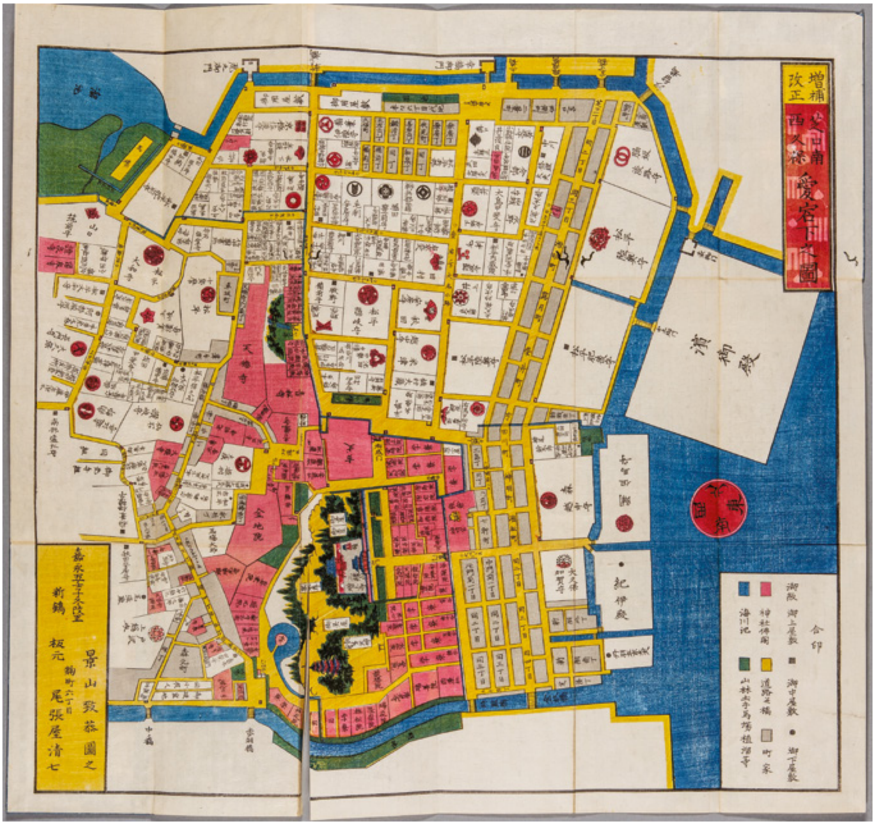
The first record of Japanese mapmaking dates from the seventh century; the earliest extant maps date from the eighth century. The first known Japanese visual representation of the archipelago is attributed to Gyoki Bosatu (668–749); the earliest surviving map of all of Japan, a Gyoki-style[50] map, dates to the 1300s. A later Edo-period copy drawn with black ink also shows the use of red to represent routes.[51] On another fourteenth-century Gyoki-style map of

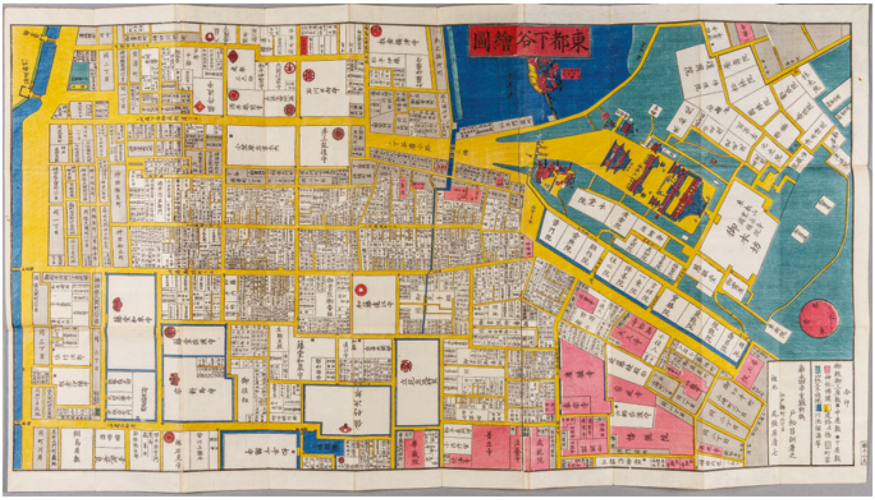
48 E-Mail correspondence with Martin Heijdra, 25 February 2020.

49 To achieve a profound understanding of the colouring of Japanese maps, numerous compilations of Japanese maps have been consulted as well as the numerous digitized Japanese maps at different institutions worldwide and the map collection held in the Museum am Rothenbaum. See Wigen, Sugimoto and Karacas 2016, Kerlen 1996, Unno 1994a, Onodera and Hirai 2021. For a general overview of “Old Japanese Maps” see also Vitale, Judith: Ad fontes, Old Japanese Maps, URL: https://www.adfontes.uzh.ch/tutorium/old-japanese-maps.

50 For further and more detailed information on Gyoki-style maps see Simonova-Gudzenko 2019.

51 The map entitled *Ninnaji zo Gyoki zu* 仁和寺藏行基図 (“Ninnaji Gyoki Map”) is kept at the Kobe City Museum, no shelfmark was traceable, see Wigen 2016, 2.





FIGURES 7–8 Two nineteenth-century colour-printed partial maps of Edo, today's Tokyo (Edo Kiriezu 江戸切絵図) with legends for the signs and colours, various dimensions.
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. 12.24:24

Japan drawn in black, red lines also represent routes and red was also used for selected captions.[52]

The historian Sugimoto Fumiko distinguishes “medieval Japanese maps” (from the twelfth to the early seventeenth centuries, which used black or two or three colours) from “modern maps” (from the seventeenth to the nineteenth century [i.e., from the Edo period], which were richly coloured and relied principally on lines for the delineation of terrain; Sugimoto 2016, 10). For the production of *kuni ezu* 国絵図—giant manuscript provincial maps made for the Tokugawa shoguns by local lords throughout Japan during the Edo period[53]—a combination of colours and shapes was used to reveal administrative and military structures. Red, blue, black and white are considered to be the four primary colours in Japanese culture. On maps, red is used for roads, blue for waterways, black for boundaries and pure white squares mark castles. Green, brown, orange and others made from mixing primary colours are used for the colouring of mountains, vegetation, religious structures, watchtowers and villages. Villages are marked by oval labels coloured according to the district they belong to. Almost all *kuni ezu* from the eighteenth century follow this colour scheme. The maps were provided with a legend for the colours and the areas of the provinces that border the individual provinces shown on the *kuni ezu* are fully coloured using a single colour.[54] As Sugimoto argues, the “spatial language” of *kuni ezu* provided a “precise grammar” for each province, in which a system of colours and geometric labels played an important role. This colour-coding system was also applied to other maps.[55]

Pictorial maps of villages or *mura ezu* 橡邑繪圖 belonged to the most common types of maps produced during the Edo period. They show settlements, fields and common land and served as a basic source for administrative officers

---

52 This map is entitled *Nihon fuso koku no zu* 日本扶桑国之図 and kept at the Hiroshima Prefectural Museum of History, see https://mainichi.jp/english/articles/20180616/p2a/00m/0na/021000c, no shelfmark.

53 The Tokugawa shogunate was the last feudal Japanese military government which existed between 1603 and 1868 (also known as the Edo period). The heads of government were the shoguns. The *kuni ezu* were usually provided with the names of the shogunal officials responsible for making the map.

54 See for example the *Tenpō Kuniezu—Echigo-no-kuni Takada Nagaoka* (“Map of Takada Domain and Nagaoka Domain of Echigo Province in Tenpō area”), from the National Archives of Japan Digital Archive, made in 1838: https://en.wikipedia.org/wiki/Kuniezu#/media/File:Echigo_Takada_Nagaoka_Map_in_Tenpo_era.jpg. For an earlier example of a *kuni ezo* (of Genroku province, dated 1696, kept in the National Archives of Japan) see Goree 2020, 177; a digital image of the map can be accessed here: https://www.digital.archives.go.jp/gallery/en/0000000222.

55 Sugimoto 2016, 49–50. For a detailed overview of these maps and further numerous examples, see the comprehensive study by Onodera and Hirai (2021).

to understand the geography and economy of a region. They were commissioned by feudal lords, produced by literate peasants and were also provided with a legend for the colours. The colouring of these maps also followed a uniform scheme: blue streams, red roads, yellow and brown fields, black houses and green forests. Not least because of the uniform colouring, the quantity and quality of water, fields and forests these maps were easy to read for rural officers (Komeie 2016, 57).[56]

On many national maps of Japan or *nihon zu* 日本図 the borders of the various prefectures were coloured in different colours to distinguish them from each other, for example on the seventeenth-century *Nihon koku nozu* 日本國の圖 ("Map of Japan").[57] Red, green, yellow, pink but also black were the most common colours used for outline colouring. Just, on a few maps borders were coloured with two colours on each side of the black border lines, such as the map entitled "Kaiserreich Japan, Ise-Land, Shiroko" drawn by Daikokuya Kōdayū 大黒屋 光太夫 in 1789.[58] There also exist maps of Japan showing the eight different regions with different border colouring. A striking feature in this context is the very wide outline colouring found in some cases, such as on Kabai Tatsunosuke's *Meiji kaisei Dainippon meisai zenzu* 明治改正大日本明細全図 ("Detailed and Total Map of Greater Japan") made in 1886.[59]

Numerous city maps—in particular those of the three major cities of Kyoto, Osaka and Edo—were produced in eighteenth- and nineteenth-century Japan as multicoloured woodblock prints. On most of these maps the streets were coloured yellow or red (or left uncoloured), the rivers blue, and the green areas such as parks green (see, for example, Fig. 9).[60] Different colours were also

56 See the anonymous1800 manuscript map *Ōmi no Kuni Kōga-gōri Kunugino-mura ezu*, kept in the Open Collection of the University of British Columbia, Japanese Maps of the Tokugawa Era Collection, shelfmark G7964.K8 G4 1800z O6 (https://open.library.ubc.ca/collections/tokugawa/items/1.0223015) and the manuscript *Map of Shimo-Shinano Village, Kasugai County* (*Kasugai gun Shimo-Shinano mura ezumen* 春日井郡下品野村絵図面) by Zenshichi 善七 and Soeman 惣石衛門 in 1841, in the Tokugawa Institute for the History of Forestry in Tokyo, published in Komeie 2016, 56.

57 This map is held in the Meiji University Library in Tokyo (Ashida Map Collection): http://www.lib.meiji.ac.jp/perl/exhibit/ex_search_detail?detail_sea_param=9,105,0,b.

58 The map is held in the Asch collection at the Niedersächsische Staats- und Universitätsbibliothek (SUB) Göttingen, shelfmark: 2° Cod. Ms. Asch 284; for a digital image see: https://commons.wikimedia.org/wiki/File:Daikokoya_Kodayu_-_Landkarte_von_Japan.jpg.

59 An exemplar of this map is in the David Rumsey Map Collection at Stanford University, list no. 10740.002; a digital image is available at https://www.davidrumsey.com/luna/servlet/detail/RUMSEY~8~1~331861~90100250: 明治改正大日本明細全図—Meiji-kaisei-Dainippon.

60 For further examples see the nineteenth-century map of Kyoto (*Shinzō saiken Kyō ezu daizen* 新増細見京絵図大全) ["New Detailed Illustrated Map of Kyoto"], held in the John

used to distinguish different status groups or *mibun* of residential areas.[61] Due to the increase of touristic travel at the beginning of the nineteenth century, so-called *kiri ezu*—maps of city districts—were made for the capital Edo.[62]

FIGURE 9 *Bansei on Edo ezu* 萬世御江戸繪圖 ("City map of Edo/Tokyo"), Japan woodcut colour print made in 1849 by Toto Shoji 東都書肆. 68 × 88 cm/35 × 15 cm. © MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. A 968

Rylands University of Manchester Library, classmark: Japanese 94, https://www.digitalcollections.manchester.ac.uk/view/PR-JAPANESE-00094/1, the nineteenth-century maps of Osaka (*Zoshu kaisei Sesshu Osaka chizu* 増修改正攝州大阪地図) and Edo (*Bansei on Edo ezu* 萬世御江戸繪圖) ["Augmented and revised map of Osaka in the province of Settsu" and "Map of Edo"] (David Rumsey Map Collection at Stanford University): http://japanmaps.davidrumsey.com/luna/servlet/detail/RUMSEY~9~1~22918~90030201; http://japanmaps.davidrumsey.com/luna/servlet/detail/RUMSEY~9~1~23376~50064:Bansei-on-Edo-ezu-.

61 See for example the map of Edo in Toby 2016b, 78.

62 See for example the set of *kiri ezu* made between 1849 and 1862, held at the National Diet Library of Japan: https://dl.ndl.go.jp/info:ndljp/pid/1286255?__lang=en.

All of these maps can be folded into the same format and were kept in a box made for the purpose. Five colours were used in the printing process (besides black for the contours), with their meaning indicated in a legend: yellow was used for roads and bridges, red for temples and shrines, blue for water, and green for woods, meadows and horse-drawn trams. The properties of the so-called 'sword-bearing nobles' (the samurai warrior caste) are white (uncoloured) while the districts inhabited by the middle class are printed in grey. Famous temples, shrines, and guardhouses are represented as pictographs. Streets with a steep incline are marked with hatching.

Panoramic maps of cities, larger regions, itineraries and famous places in a pictorial bird's-eye view were also produced as multicoloured woodblock prints on a grand scale in Japan. Most of them were made in the style of landscape paintings and lavishly coloured. The history of pictorial route maps can be traced back to the seventeenth century. The oldest known Japanese printed itinerary map of Japan—the *Tōkaidō michiyuki no zu* 東海道路行之圖 ("Itinerary map of the Tōkai road")—dates back to 1654 (Unno 1994a, 422).[63] Folding maps with illustrations of many Japanese famous places (*meisho zue* 名所圖會)[64] as well as of sea and land routes were produced in large numbers from the beginning of the eighteenth century and enjoyed great popularity. Cartouches in different colours (in most cases red, see Fig. 10) contain the names of the individual stations and bright yellow (or white) cartouches those of topographical features such as mountains.[65]

3.3 *Colours on Korean Maps*

The consultation of several Korean compilations of Korean maps,[66] as well as the numerous digitized Korean maps at different institutions worldwide, and

63 A digital image of the map is available at https://open.library.ubc.ca/collections/tokugawa/items/1.0167749.

64 Next to the folding maps, printed books of *meisho zue* were produced on a large scale in the late Edo Period; for a detailed account on these geographical books see Goree 2020.

65 See for example the 1839 *Tōkaidō gojūsantsugi ichiran* 東海道五十三次一覧 ("Panoramic view of the fifty-three stations of the Tokaido Highway") by Ando Hiroshige (1797–1858) and the 1852 *Dai Nihon kairiku meisho zue* 大日本海陸名所圖會 ("Panoramic view of the noted places in the land and sea of Great Japan") by Utagawa Sadahide (1807–1873), both held in the University of British Columbia): https://dx.doi.org/10.14288/1.0216572; https://open.library.ubc.ca/collections/tokugawa/items/1.0222844.

66 Namely the exhibition catalogue *500 Years of the Joseon Dynasty Maps* by Jang et al. (Seoul 2018), *Kukt'o ŭi p'yosang/ Han'guk Kojidojip P'yŏnch'an Wiwŏnhoe* (*Land in Old Maps*), edited by Han'guk Kojidojip P'yŏnch'an Wiwŏnhoe (Seoul 2012) and *Baeg du san go ji do jib: han gug go ji do sog ui baeg du san* (*Window to Mount Baekdu: Mount Baekdu in the old maps of Korea*) by Yang Bo-gyeong, I Hyeon gun and Mun Sang-myeong (Seoul 2016).

FIGURE 10 Japanese *Dai Nihon kairiku meisho zue* 大日本海陸名所圖會. ("Panoramic map of land and see sights of Great Japan") made by Utagawa Sadahide 歌川貞秀 (1807–1873) in 1852. Red cartouches mark different places. 37 × 146 cm.
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. A 967

not least the map collection held in the MARKK, has shown that Korea also has developed a very rich tradition of mapmaking for over one and a half millennia. Most of the surviving Korean maps were produced during the Joseon dynasty (1392–1897). The oldest surviving Korean-made map, and one of the oldest East Asian world maps, is the *Kangnido* (short for *Honil Gangni Yeokdae Gukdo Ji Do* 混一疆理歷代國都之圖, "Map of Integrated Lands and Regions of Historical Countries and Capitals"), painted in 1402 and copied in the 1470s on silk and still preserving its colours well (Ledyard 1994, 245).[67] The land is left uncoloured on this map, while the oceans, lakes and rivers are coloured dark green or blue. Red-coloured signs were used to indicate places on the map.

Most surviving Korean national and provincial maps date from the seventeenth century or later (Ledyard 2008). Maps of Korea after the *Kangnido* are usually classified in four groups: (1) the fifteenth to the mid-seventeenth century Jeong Cheok 鄭陟 (1390–1475)-style maps; (2) the *Sungnam*-style maps, popular until the end of the nineteenth century; (3) the Jeong Sanggi 鄭尙驥 (1678–1752)-style maps, which began to appear during the first half of the eighteenth century and were common until the mid-nineteenth; and (4) Kim Jeong-ho's 金正浩 maps, produced from 1834 to 1864 (Ledyard 1994).

Although many Korean maps differ with regard to their geographical information and even graphic styles, they share similarities in their colouring. Most of them follow the characteristic colour system of East Asian maps, leaving the land uncoloured and colouring the rivers and the sea. The most distinctive characteristic of all these maps is the strong visual representation of mountains, showing the special physical and spiritual relationship that Korean people have with their mountains (Fig. 11). Mount Baektu in the north, representing the sacred origin of the nation, is usually linked to all other mountain

67 This map is held in the Ryokoku University Library, Kyoto, Japan (no shelfmark).

FIGURE 11 Late eighteenth-century Korean Map of the Hwanghae Province (*Huanghae-do* 黃海道, most probably made by Shin Gyeong-jun 申景濬 (1712–1781). The typical colouring system on Korean maps with the sea and the rivers being coloured in full while the land is uncoloured can be clearly seen, as well as the characteristic prominence given to the mountain ranges. 109 × 123 cm.
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 12.24:52

chains. These mountains were usually coloured in blue, green and brownish tones, but sometimes also left uncoloured. Red (and sometimes yellow and orange) was used for the colouring of signs for cities, military-related features and roads and some settlements. More than two colours were used for the colouring of most maps. However, there also exists a series of maps coloured exclusively in blue (sea and rivers) and red (places and routes).

During the Joseon Dynasty, particularly from the eighteenth century on, the production of maps in Korea saw a massive boom. Among the most popular and most used formats in the eighteenth and nineteenth centuries were so-called hand atlases.[68] These manuscript and printed atlases, produced in

68 For further information on the 'atlas production trend', see Dorofeeva-Lichtmann 2019.

a large variety of designs, catered for the need to show Korea from different perspectives: as part of the world and East Asia, and as an overall region and divided into its various provinces. In this respect, they embodied Korea's perception of itself as an independent nation and at the same time underlined the importance of its relations with its neighbours. Many of these atlases were coloured in a particular colour system and colour scheme using just a few colours (in many cases just red and blue, in other cases yellow was added as well). On most of the maps in the atlases, the mapmakers found methods to convey a great variety of information by skilfully combining the colours. For example, on the province maps the names of the different administrative units are given rounded or rectangular frames. The cartouches (mostly including information such as the administrative rank, the distance of the place to the capital city of Seoul, etc.) were usually outlined in red (Fig. 12).

All Korean provinces were divided into two sectors with regard to military administration. On some maps, the division into a "right" (右) and a "left" (左) sector was marked by red lines, the designation being reinforced by either red or blue colouring (Fig. 13). Korean atlases illustrate in exemplary form the use of colours to communicate administrative information on maps.

FIGURE 12 Detail of an eighteenth-century Korean province manuscript map from an atlas (*Yeojido* 與地圖), from an unknown mapmaker. Signs in different colours and shapes were used to encode information about specific places, further information is provided inside and outside the cartouches. 22,5 × 35,8 cm (entire map).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 82.93:1

FIGURE 13 Nineteenth-century map of the Korean province Hwanghae (*Hwanghae-do* 黃海道) from a woodblock printed and hand-coloured hand-atlas (*Yeojido* 與地圖), from an unknown mapmaker. The division in the right and left sectors can clearly be seen. 27,1 × 33 cm.
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 12.24:50

A distinctive characteristic of Korean cartography is the use of the *wuxing*-theory for the colouring of national maps: circular dots, ovals or squares demarcating administrative bodies are colour-coded by province. These coloured dots help to distinguish the individual provinces, as provincial borders are not represented. Specifically, the direction and relative position of each province have a specific colour associated with the five elements theory, according to which the centre is yellow, east is green or blue, south is red, west is white, and north is black. The names of the district magistracies in each Korean province were shown in or next to circular cartouches, colour-coded according to the province they belong to, based on colour schemes provided by the mapmaker. These colour-coded geometric shapes can be found on maps from the sixteenth century onwards.[69] According to the *wuxing* scheme, the district magistracies

69 See for examples in Jang et al. 2018, which include the 1710s *Daedongyeojido*/*Territorial map of the Eastern Country* [Korea] 東國輿地之圖 (pp. 32–33), the mid-eighteenth-century

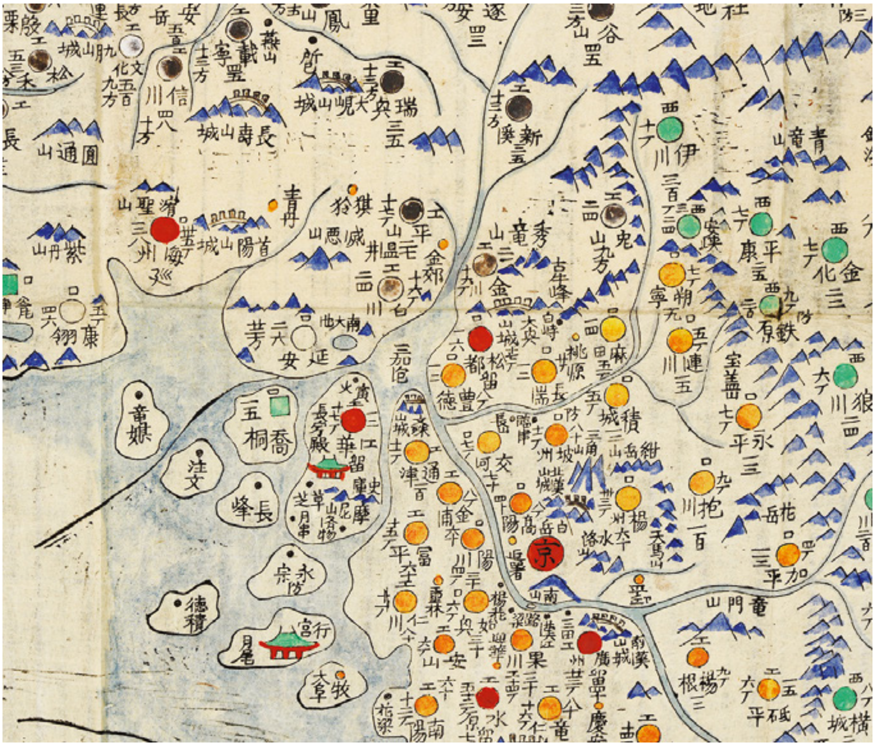


FIGURE 14 Detail of the 1820s Korean *Dori-pyo* 道里標, from an unknown mapmaker. The circles representing the district magistracies of the 'central' province around the Korean capital were usually coloured in yellow.
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 12.24:39

of the 'central' province around the Korean capital were usually coloured in yellow (Fig. 14). The colour yellow also played an important role in the colouring of imperial palaces on Korean maps. This colour scheme was used in Korea for the first time in 1463 by the cartographer Jeong Cheok 鄭陟 (1390–1475) on his *Tongguk chido* 東國地圖 ("Map of the Eastern country [Korea]") and had a major influence on the design of later maps.[70] With occasional divergences and variations, it continued to be used well into the nineteenth century.

Dongguk Daejido/*Grand Map of the Eastern Country* [Korea] 東國大地圖 (pp. 78–83), the late-eighteenth-century *Comprehensive Geographic Map of* [the Country in] *the Left* [Eastern] *Sea* [Korea] 海左一統全圖 (pp. 34–35) and the mid-nineteenth-century *Haejwa Jeondo* 海左全圖 (pp. 10–13); https://www.museum.go.kr/site/eng/relic/search/view?relicId=2502); and https://www.museum.go.kr/site/eng/relic/search/view?relicId=4336.

70 Ledyard 1994, 291–92, and Pegg 2014, 11.

Next to these standardized atlases, town and county maps as well as military maps were made by a great variety of local hands in different styles. Since the background of most local mapmakers was more in painting and drawing than in cartography, the results are evident in hundreds of local maps in the style of bird's-eye view landscapes (Ledyard 1994, 236). Thus, it is not surprising that their colouring follows the principles of landscape painting, such as the choice of colours and the strong visual representation of mountains.

In summary it can be stated that in Korea the colouring of maps played a significant role for both manuscript as well as printed maps.

4 Putting Colour on Maps

After a brief overview of the technologies used for the printing of (coloured) maps, this section will provide insight into the process of hand-colouring maps and the people involved in this process.

We identify five different types of maps in East Asia: uncoloured manuscript maps, coloured manuscript maps, uncoloured printed maps, hand-coloured printed maps, and printed maps in colours. Before the introduction of colour printing, maps were, first, produced as monochrome, and coloured later: colouring used to be a practice and an action deferred in time and/or relocated in space.

From a merely technical point of view, colouring a map means applying dyes or pigments (or a mixture). The different terms in East Asian languages used to describe the practice of colouring give some insights into different types of colouring. Most of the terms used for the colouring of maps were also used for the colouring of prints. The Chinese terms for colour are *yan* 颜, *se* 色 or *secai* 色彩. The term *zhuose* 着色 ("to apply colour") is generally used for 'colouring' and *yan liao* 颜料 is used for 'colourant'. Different terminologies also exist for the different techniques used to apply colours on paintings, such as *ran* 染 ("to dye; to add colour washes to a painting") or *dan ran* 淡染 ("light wash", *dan* means "light in colour") (Yu 1988, 49). The general term for 'colourist' is *shanyong secai zhe* 善用色彩者 ("somebody who makes good use of colours"). In Japanese and Korean, the same Chinese characters were used for these terminologies. Cordell Yee noted that the verb most often used to describe the manufacture of manuscript maps is *hui* 繪 ("to paint"), especially using colour (Yee 1994c, 102). The variety of these selected terms used for 'colouring' in East Asia in a broader context shows that their linguistic origin is closely connected with the term for 'colour' or with a certain technical context.

4.1 *Monochrome Printing of Maps in East Asia*

Woodblock printing or xylography was the oldest technology for printing many copies of maps in East Asia. It was invented in China in the eighth century and quickly spread throughout East Asia. Woodblock printing remained the dominant printing technique until the nineteenth century in China, although it was not the only technology available to Chinese (and Korean and Japanese) printers. Movable-type printing developed in the eleventh century. This technology did not become popular in East Asia, since the nature of the Chinese language required the ability to reproduce up to several thousand characters and made the use of movable-type fonts financially impractical for most printers. As long as the carving costs remained low, xylography was more attractive and block printing remained the dominant print technology until the coming of lithography in the nineteenth century.[71] It should also be mentioned that maps were also produced as ink rubbings from stone tablets in China. The *Yujitu* 禹跡圖 ("Map of the Tracks of Yu")—the oldest surviving map showing a grid scale—belongs to the most famous maps produced as ink rubbing. It was derived from a stone tablet engraved in 1136. One undated rubbing kept in the National Library of China collection was made of red ink (Ting 1997, 21 and 33). Another undated rubbing of a map made with red ink—the *Jinsheng yudi quantu* 晋省餘地全圖 ("Complete Map of Shanxi Province")—was taken by a stone tablet engraved in 1794 by Li Baofu 李宝甫.[72] Coloured ink, in particular blue ink, was also used for the production of woodblock prints, such the *Da Qing wannian yitong dili quantu* 大清萬年一統地理全圖 ("Complete maps of the Everlasting Unified Qing Empire"), made in 1810 by Huang Qianren 黃千人 (1694–1771). Several copies of this map were printed in blue in the nineteenth century and also became known as the "blue maps of China".[73]

In his study on the surviving historical woodblocks for printing in China, Xiao Dongfa stated that they can be classified into three categories: woodblocks for printing books, for printing Buddhist sutras, and for printing pictures (2010, 71). He does not assign woodblocks for printing maps to a special category, he

71 On early woodblock printing in China see Brokaw 2005, 8–9, Dennis 2015, 6, Wu 1936, Wu 1940, Wu and Wu 1943, Chibbett 1977, 33.

72 This map is held in the China National Library in Beijing *Zhongguo guojia tushuguan* 中国国家图书馆 (no shelfmark) and reproduced in Yan et al. 1998, 212–13.

73 One of these maps is kept in the China National Library in Beijing *Zhongguo guojia tushuguan* 中国国家图书馆 (no shelfmark) and reproduced in Yan et al. 1998, 222–23. For a digital file of a copy held in the Library of Congress (shelfmark G7820 1816) see: https://lccn.loc.gov/gm71005060.

only mentions "a few [woodblocks] for printing the local maps".[74] The study of numerous Chinese printed maps has shown that most of them were printed by authors and publishers from woodblocks until the nineteenth century.

In Japan, books had been printed from woodblocks since the eleventh century, but single-sheet maps were not printed until the seventeenth century. According to the map historian Uesugi Kazuhiro, the "explosion of woodblock printing in the Edo period" also affected the production of maps, in particular maps of the cities Edo, Osaka and Kyoto. The demand for such maps was stimulated by the increasing trend of leisure travel in Japan. The first published map of Kyoto—*Miyako no ki* 都記 ("Record of the Capital")—was printed about 1626, followed by many others.[75] The earliest Japanese map of Japan printed on a single sheet is the anonymous *Dainihonkoku jishin no zu* 大日本国地震之図 ("Earthquake map of Great Japan") of 1624 (Unno 1994a, 410, and Unno 1994b).[76] Japanese woodblock prints were in general of very high quality, and in fact, some woodblock prints might have been taken by Europeans for copperplate engravings after the vast improvements in line cutting by the middle of the nineteenth century (Unno 1994a, 349).

The technique of printing maps from woodblocks also reached a high level in Korea and is well documented for individual maps such as the *Daedongyeojido* 大東輿地圖, the "Territorial map of the Great East [Korea]", printed in the 1860s (see also the case studies in Section 6).[77]

Although copper engraving was introduced in China in the early eighteenth century by the Italian missionary Matteo Ripa (1682–1746), woodblock printing remained the dominant printing technology for maps until far into the nineteenth century in East Asia. One of the first maps printed from copper plates in China was the *Kangxi huang yu quan lan tu* 康熙皇輿全覽圖 ("Complete map of the Empire of the Kangxi Era") printed in 1719.[78] The first map to be engraved on copper plates in Japan was the world map *Yochi zenzu* 地球全圖

74 Xiao mentioned such blocks in connection with one of the largest Sutra-printing houses, the famous Dege Sutra Printing House or *Dege yin jingguan* 德格印经院 in Dege County of Sichuan Province (Xiao 2010, 71).

75 Uesugi 2016a, 67–68. A copy of this map is kept in the Kyoto University Library (no shelfmark was traceable) and was reproduced in Uesugi 2016a, 66.

76 For a detailed study of this map see Saburo Noma 1974. For a digital image of this map, see https://bunka.nii.ac.jp/heritages/detail/455249. Another version of this map was published in Onodera and Hirai 2021, 154.

77 See the very comprehensive and detailed publication *Kim Jeong-ho and his Daedongnyeojido, Territorial Map of the Great East*, published by the National Museum of Korea in 2007.

78 The 1721 version of this map is published on https://qingmaps.org/maps/kangxi-1721 (Cams, Rodenburg and Sam-Sin 2007).

("Map of the earth"), made in 1792 by Shiba Kokan 司馬江漢 (1747–1818) (Unno 1994a, 435).[79] In Korea, copper engraving was not used to produce maps before the late nineteenth century.

4.2 *Hand-Colouring of Maps in East Asia*

Not much is known about the people who coloured maps by hand in East Asia. Sivin and Ledyard stated in their *Introduction to East Asian Cartography* that "Anyone familiar with East Asian art is aware that painting and calligraphy, depiction and writing, share methods, materials, languages of gesture, and aesthetics. […] cartography was not the province of specialists. Any magistrate was expected to draw a presentable map when one was needed, because he was trained to write beautifully and to paint. […] there is no evidence that even the central government had a special cartographic staff expect when special projects made it necessary to organize one" (1994, 29). For example, the geographer Komeie Taisaku mentioned that Japanese *mura ezo* or village maps were produced not by experts or painters, "but by literate peasants who had the ability to draw a pictorial map" (2016, 57). These people most likely also coloured their maps.

Maps in East Asia were therefore made by a great variety of local people in different styles. The presumption is that professional map colourists did not exist. Manuscript maps were made by people of various professions who almost certainly coloured their maps themselves. The colouring of printed maps also seems to have been executed by different groups of people, such as painters, untrained workers, and specialized mapmakers. For example, the most eminent geographer and cartographer of the late Joseon period, Kim Jeong-ho 金正浩 (*c.*1804–*c.*1866), made it a rule to apply colours to the woodblock prints of his famous *Daedongyeojido* 大東輿地圖 or "Territorial Map of the Great East [Korea]".[80] Although it is not recorded who carried out the colouring, we can assume that Kim was actively involved in the colouring process. Nevertheless, most individuals involved in map colouring remained anonymous.

In Japan, artists played a dominant role in mapmaking during the Edo period. However, it remains doubtful whether printed maps were coloured by

79 For a digital image of the map, see https://www.loc.gov/resource/g3200.ct007100/.

80 For further and more detailed information on the *Daedongyeojido*, see Jang 2006 and the book *Kim Jeong-ho and his Daedongnyeojido, Territorial Map of the Great East*, published by the National Museum of Korea in 2007. The colouring of the *Daedongyeojido* is discussed in detail in the case studies in this book. For a digitized version of a woodblock print kept in the National Museum of Korea (Accession Number Sinsu 19997) see: https://www.museum.go.kr/site/eng/relic/represent/view?relicId=4502.

artists or by untrained staff. Very little is known about Japanese woodblock carvers and printers. While it is known that their apprenticeship lasted many years (up to ten years for the carvers), no information has been traceable about the colourists' training (Salter 2013, 60). In the early seventeenth century, single-sheet prints produced in the main publishing centres in Osaka, Kyoto and Edo (today's Tokyo) were hand-coloured by contract workers about whom practically nothing is known. Women were probably involved in such colouring work.[81] Since the colourists could not keep up with the growing demand for coloured prints, and hand-colouring added considerably to the cost of the final prints, the need to speed up the technique became real and led to the development of successful colour printing in Japan in the eighteenth century (Salter 2013, 10). As mentioned above, this also applied to the colour printing of maps in that region.

The uniform colour schemes and colour codes found on many maps suggest that colouring rules were not developed individually by their makers (and colourists) but followed fixed rules. This applies, for example, to many Chinese flood control and embankment maps, Korean and Chinese province maps, and Japanese city maps. The signs used on many Chinese and Korean maps are generally treated as self-explanatory and it was rather unusual to provide a key to explain standard signs. Taking these factors into consideration, it is possible that the use of specific colours for the colouring of maps and the respective rules had been internalized to a very great extent by mapmakers (and colourists). Very few sources referring to map colouring instructions or descriptions are extant. A few examples of this type of text may be found in eighteenth-century China: hydrological maps produced during the reign of the Qianlong Emperor (r. 1735–1796) were usually accompanied by texts. In many cases, these maps were drawn to accompany so-called memorials to the throne. Such memorials sometimes contained the description of the colour schemes employed on the maps, such as "between the dykes, [referring to an unknown map] used a deep green. Within deep waters, it used a deep blue. For hidden sandbars, it used black ink" (Yee 1994c, 102).

Something similar happened on a few Korean maps: in the foreword to an album including the *P'alto chido* 八道地圖 ("Maps of the Eight Provinces"), which was most probably made by the cartographer Jeong Sanggi 鄭尙驥 (1678–1752), the author stated concerning the colouring:

81 Information from the artist Rebecca Salter (President of the Royal Academy of Arts in London, who intensively studied and practiced traditional Japanese woodblock printing for many years), via e-mail, February 2021.

> On the assignment of distinctive colouring, Kyonggi is solid yellow, Hoso white with red, Honam [Cholla] solid red, Yongnam [Kyongsang] blue with red, Yong-dong [Kangwon] solid blue, Haeso [Hwanghae] solid white, Kwanso white with black, and Hamgyong solid black. Green is used for mountains, blue for rivers. Red lines indicate major routes on land or sea; yellow lines show borders between the left and right divisions [of provinces]. A platform-shaped sign with dotted red marks a fire signal; a crenellation with solid white indicates a mountain fortress [*sansong*]. If garrisons or district towns are walled, a white line is drawn outside; if post stations or command posts are within enclosures, they are distinguished by blue and yellow, respectively.
>
> Unno 1994a, 307–9

However, such accounts of the coloring schemes written by the cartographer for specific maps are very rare.

In general, map colouring seems not to have been a different practice from painting in East Asia. Correctly applying colours was a skill developed with hands-on experience. The Chinese painter Yu Feian 于非闇 (1889–1959) stated that a painter should acquire experience to be able to achieve a lively use of colour and that "skill in applying colors has no fixed methods; skill in mixing colors has no set formulas" (Yu 1988, 52). Based on the study of colouring practices (such as those described in Yu 1988 and Tsien 1985), it can be stated that the process of colouring or wash-colouring a map generally took place in several phases. As a first step, the surface of the map should be sized or pre-treated with alum water or glue to preserve the paper, to avoid the colours soaking into the paper and the running of ink.[82] Colours were added after the paper dried.

Various types of brushes were used for multi-colour woodblock printing and hand colouring, such as brushes for applying the sizing agent. Because of the difficult cleaning process, a separate brush was normally used for each colour. The brushes were washed thoroughly after use and dried.[83] Different techniques were employed to draw and colour maps. Before the invention of colour prints in Japan in the seventeenth century, maps were coloured by brush or by *kappa-zuri* (stencilling), in which cut-out patterns were placed on the printed maps and colours applied over them. Since neither the paper nor the woodblocks came in large sizes, several sheets of paper were joined together to produce large maps. To produce very large maps, a stronger paper was pasted

82 For a description of the process of sizing Japanese paper, see Salter 2013, 46–48; for a description of sizing paper in China see Tsien 1985, 73–74.

83 For a detailed account of the different kinds of brushes, see Salter 2013, 33–37.

to the back of these conjoined sheets to reinforce them. The strength of the paper made it possible to make the maps in the form of scrolls and folding books. In contrast to China and Korea, maps in atlas format were rare in Japan. The large size of most Japanese maps can be attributed to the availability of floor space. After being consulted, they could be rolled up or folded and stored in a small area. The paper was thin, strong, and flexible but also rough, and the brush traditionally used for writing and drawing was incapable of making fine lines, although it was good for colouring (Unno 1994a, 349–50). As traditional Japanese paper is very absorbent, its surface had to be sized with a mixture of animal glue and alum before the production of multicolour prints (Salter 2013, 46).

4.3 *Colour Printing of Maps in East Asia*

The technique of making and using wood blocks did not change substantially over a period of twelve hundred years. One major technical innovation was the invention of colour printing in East Asia (Chibbett 1977, 34–35). According to Wu Guangqing, who has worked extensively on the history of printing a technique called *taoban* 套板 ("set of blocks"), it was invented in China during the Ming dynasty (1368–1644) and was very popular in the late sixteenth and first half of the seventeenth century. A set of woodblocks—inked in various colours—were separately pressed, one time each, on the paper. One of the earliest examples of colour woodcuts in five colours was printed in 1606 by Huang Yiming 黄一明 in the *Fengliu juechang tu* 風流絕暢圖 ("Pictures of the Height of Sophistication") (Edgren 2011, 126). Along with coloured illustrations using woodblocks, another type of colour printing arose: texts with punctuation and comments in colour (Wu 1940, 40–41). The *taoban* printing technique was also applied for maps, though on a very limited scale. Wu stated that "the successful use of the *t'ao -pan* process in bringing out desirable contrast was sufficiently demonstrated in the few decades that preceded the Ming dynasty in 1644. The success was so obvious that enterprising printers soon sensed its value in the production of maps. In 1643 there appeared a work in this field which merits special attention" (Wu 1940, 41). This statement refers to the *Jin gu yu* ditu 今古輿地圖,[84] the earliest extensive atlas printed from woodblocks in red and black. It is a collection of maps showing geographical areas in modern (printed in black) and ancient times (printed in red), prepared by Wu Guofu 吳國輔 and Shen Dingzhi 沈定之. Other historical atlases printed using blocks in black and red colours appeared later, such as *Lidai yu di yange tu* 歷代輿地沿革圖 by Li

84 See, for instance, the copy held in the Library of Congress: https://www.loc.gov/item/2002530058/.

Zhaoluo 李兆洛 (1769–1841) and the *Lidai yu ditu* 歷代輿地圖 by Yang Shoujing 楊守敬 (1839–1915), both geographers and cartographers of repute (Wu 1940, 41–43 and Hummel 1938, 229).[85] However, colour printing never became as commercial successful in China as in Japan (Chibbett 1977, 36).

The exact chronology of the early years of colour printing in Japan remains unclear. Following unrest in China in the second half of the seventeenth century, many artists and writers fled to Japan, possibly taking their knowledge of colour printing with them (Salter 2013, 9). According to Chibbett, in illustrations in printed books colour was applied by hand until the seventeenth century; the earliest authenticated Japanese book including colour-printed illustrations was a mathematical treatise produced in the first half of the seventeenth century (1977, 35–36). We can assume that printed maps were also coloured by hand at least until the seventeenth century in Japan. Multicolour printing in cartography appears to have been adopted in Japan in the second half of the eighteenth century, such as for example for the production of the *Chōsen Ryūkyū Ezo narabini Karafuto Kamusasuka Rakkojima nado sūkoku setsujō no keisei o mirutame no shōzu* ("A Small Map for the Purpose of Seeing the Shapes of the Numerous Bordering Countries of Korea, Ryokyu, and Ezo, as well as Sakhalin, Kamchatka, Sea-Otter Island, etc."), by Hayashi Shihei 林子平 (1738–1793), published in Edo by Suharaya Ichibēi in 1786.[86]

The invention of *kento* 見当 or registration marks in Japan led to a huge improvement in the Chinese system of registration[87] (Salter 2013, 10). The simple system of two shallow carved marks on the woodblock enabled Japanese printers to produce ambitious multicoloured prints. Skilful control of the materials and the enormous accuracy allowed the production of colour prints to flourish.[88] This also includes the production of multicoloured maps that were produced in very large numbers during the Edo period.[89] The colourants used for traditional Japanese woodblock prints and for the colouring of prints were always water-based. The four basic colours were black, yellow, blue and

85 https://lccn.loc.gov/2002530058.

86 A copy of the map is kept in the George H. Beans Collection, University of British Columbia Library (Call Number G7962 .E9 1785 H2 Map 1), reproduced in Toby 2016a, 24.

87 Registration is the process by which a printmaker will line up more than one colour within a print so that all colours register exactly in the right place on top of each other. Registration marks are used to align separate colours of ink when printing pages with more than one colour.

88 For a detailed account of the various printing techniques used in Japan, see Salter 2013.

89 For a comprehensive overview on mapping Japan and map production during the Edo period, see Yonemoto 2013.

red. Other colours were achieved by mixing or overprinting.[90] In contrast to China and Japan, in Korea printed maps in colour from woodblocks did not appear before the nineteenth century.

Lithography and the related process of collotype printing had been used to print Chinese texts from 1828 onwards by Protestant missionaries (Kurtz 2010, 90). The first magazine printed in the Chinese mainland, in 1833, was the *Chinese Magazine* (*Dongxiyang kao meiyue tongjizhuan* 東西洋考每月統記傳). It was apparently produced by lithographic printing on high-quality bamboo paper, and it included hand-coloured maps and was printed in six hundred copies. Yet, the boom in lithographic technology which finally marginalized woodblock printing only came with the introduction of photolithography in the late 1870s (Janku 2010, 131). The first lithographs were printed in Japan in the mid-nineteenth century and this technology became popular in the second half of the nineteenth century. In Korea, this technique was only adopted towards the end of the nineteenth century (Ok 2013, 58).

5 Colour and Science

Since no explicit colouring manuals for maps could be found for East Asia, a large part of the information about colouring maps derives from manuals for painting. Such manuals provided information about producing and mixing dyes and pigments and how to paint and draw with these colourants. One such manual is the *Jiezi yuan huaxiang* 芥子園畫像 ("Manual of the Mustard Seed Garden"), the most widely-used painting manual in China which was first compiled in the late seventeenth century.[91] The richest source on Chinese painting colours and their historical development is the *Zhongguohua yanse de yanjiu* 中國畫顏色研究 ("Research on Chinese Painting Colours"), written by the painter Yu Feian 于非闇 and first published in Beijing in 1955 (Yu 1988). Alongside the practical knowledge acquired through years of painting practice, the author provides a detailed account of the pigments and dyes used in China, compiled from diverse written Chinese sources. Yu's manual also includes a detailed list and table of recipes for mixing colours (Yu 1988, 33–34, 68). Early general overviews on the pigments used in Japan were provided by Rokuro Uyemura in his paper "Studies on the Ancient Pigments in Japan" (Uyemura

90 Salter 2013, 26. The first change of this palette came with the introduction of aniline colours from Europe in the nineteenth century.

91 Modern Reprint: Chao 1979. For further information on the *Jiezi yuan huaxiang*, see Hu 2000, 79–80.

1931), and by Edward Forbes (1932), followed by later publications by Yamasaki and Emoto (1979) and *Pigments in Later Japanese Paintings* by Fitzhugh, Leona and Winter (2003), based on the pigment analysis of 500 paintings from the late sixteenth to the late nineteenth century.[92] Pigments used in Korean large Buddhist paintings were analyzed on a large scale by researchers of the Korean National Research Institute of Cultural Heritage (NRICH) and published in Korean in numerous research reports.[93] Comprehensive research papers on material analysis were also published in English, for example by Nam et al. (2016), and Yang, Lee and Yi (2021).

Textual sources and scientific analysis of the maps themselves represent two of the most important sources to explore the colour palette of mapmakers and map colourists. Painting manuals not only provide information about the range of colourants but also about the availability of pigments, recipes to prepare colour, and their practical use. The material scientific analysis enables us to find out more about the material composition of colours on maps. There is considerable evidence that the same colourants used for painting were also used for colouring maps in East Asia.

5.1 *The Scientific Analysis of Map Colourants*

The diversity of modes and techniques for colouring maps is overwhelming and ranges from the detailed elaboration of individual scenes and decorative adornments to schematic, very sparingly applied, transparent colourations. The diverse group of the colourants can first be divided into two subgroups—pigments and dyes. In preparing colourants, pigments and dyes undergo different procedures. Pigments are not soluble in bonding agents and solvents, and so they are visible as small particles when viewed through a microscope. Dyes dissolve and can not be made out as individual particles. This plays a role in the choice of a suitable material scientific analytic process.

92 The Freer Gallery of Art, Smithsonian Institution (Washington, DC), owns six hundred Japanese paintings, drawings, and sketches of the ukiyo-e school (depicting the daily life of ordinary people of Japan). Seventeen pigments were identified on 500 of these paintings on silk and paper supports. Identification methods were polarized-light microscopy, chemical microscopy, and x-ray diffraction, with limited use of scanning electron microscopy with energy-dispersive x-ray analysis (see Fitzhugh, Leona and Winter 2003, 1).

93 These reports were published in Korean and can be downloaded as pdf for free: https://www.cha.go.kr/cop/bbs/selectBoardArticle.do?nttId=79405&bbsId=BBSMSTR_1021&pageIndex=12&pageUnit=10&searchCnd=&searchWrd=&ctgryLrcls=&ctgryMdcls=&ctgrySmcls=&ntcStartDt=&ntcEndDt=&searchUseYn=&mn=NS_03_08_01. See for example: http://116.67.83.213/cha_media.html?file=/NEW_PDF/38_청룡사%20영산회%20괘불탱.pdf.

As a general rule, pigments are inorganic compounds, metallic salts like oxides, carbonates, or sulfides, which can easily be identified by the presence of a typical element (so-called 'marker elements'). Along with natural pigments which can be obtained as minerals from corresponding deposits, artificial pigments have been produced. Natural dyes, on the other hand, are obtained from plants, fungi, or insects by purifying or chopping up the relevant parts and then extracting or fermenting the dyes with suitable aqueous solvents. The solution containing the dye is filtered and then either dried or stabilized with a pickling solution or by adding a substrate, for example alum. There are countless recipes for producing organic dyes from natural raw materials. A wide variety of synthetic organic dyes (and pigments) has been available since the beginning of coal tar dye chemistry in the middle of the nineteenth century.

After viewing the maps through a microscope, we undertook investigations with non-destructive, non-invasive methods. These techniques (also called natural scientific methods), such as X-ray fluorescence analysis (XRF), UV-VIS spectroscopy, and vibrational spectroscopy (Raman), reveal which dyes and pigments were applied.[94] They are particularly useful when documents about the use of colourants are fragmentary or not available at all. Scientific methods are playing an increasingly significant role in investigating art and cultural artefacts, and along with imaging analyses, such as computer tomography and radiography, material analyses are very important.

The procedures to examine the maps include the analysis of constitutive elements (the kind and number of atoms are determined) and chemical analysis (the bonds among atoms). Modern electronic components have reduced the size of the instruments, so the devices can be brought into museums, libraries or archives, avoiding the expensive and risky transport of precious originals and favouring their conservation, as items remain under optimum storage conditions. In many cases, these methods are sufficient to carry out the analytical study of colourants. These two conditions—mobility of the equipment and non-destructiveness of the tests—were absolute requirements in our research project.

Of the great variety of material scientific investigative methods that are available, we will discuss in detail only those used in our research project. Most of the analyses presented in this book were done by applying 'radiodiagnostic examinations'. In a process known as 'excitation', light of a specific wavelength interacts with the materials to be investigated. The way this interaction occurs

94 For detailed descriptions on XRF, see Bronk et al. 2001, and Hahn, Reiche and Stege 2006; on VIS, see Hahn, Oltrogge and Bevers 2004; and on Raman, Centeno 2016.

has to do with the kind of exciting light—visible light (VIS), ultraviolet light (UV), infrared light (IR), or X-rays—and with the structure or composition of the material. After a brief disturbance, the material returns to its original basic state. These energies are transposed, orderly arrangements briefly disturbed, individual particles separated from their setting. This relaxation process leads to the release of characteristic radiation which, properly interpreted, provides indications of the composition of the investigated material. With the aid of microscopies, we applied three different illumination systems (UV, VIS, NIR), X-ray fluorescence analysis, two methods of vibrational spectroscopy, and, in addition, VIS spectroscopy and X-ray diffractometry.[95]

5.2 *The Determination of Colourants on East Asian Maps*

Using the methods and techniques just described,[96] we carried out a systematic and comparative study of nineteen hand-coloured maps (single-sheet maps, map sets, maps from atlases, scroll maps, and maps on folding screens) from East Asia, eleven maps from Korea, nine maps from China and one map from Japan.[97] These methods make it possible to gather information about the colourants used in this region, although larger research might shed even more light on this topic. With the exception of the Japanese map, which was probably made in the seventeenth century, the earliest maps in our investigation produced in China and Korea are from the (early) eighteenth century, the most recent map was produced in China and dates from the turn of the nineteenth to the twentieth century.

Sixteen of the nineteen maps examined are held in the MARKK, and the other three maps (all Chinese) are kept in the Max-Planck-Institute for the History of Science (MPIWG) in Berlin:

1. *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図 ("Maps of all lands and people") Japan, folding screen with manuscript maps, second half of seventeenth century, each panel 78 × 149 cm (MARKK 2917:09, entry in 1909 from art dealer R. Wagner, Berlin)
2. *Cheonhado* 天下圖 (version of a circular world map)

95 A detailed description of these methods can be found in the appendix.

96 See for example Castro et al. 2008a and 2008b, Kogou et al. 2016, Mendes et al. 2008, Nam et al. 2016, Stillo 2016, Yang, Lee and Yi 2021, and the numerous NRICH reports mentioned above.

97 Among the numerous colour-printed maps catalogued at the MARKK collection of Japanese maps, there is only one hand-coloured manuscript map. Our project was focused on the analysis of the colourants of hand-coloured maps. Due to the restrictions caused by the pandemic we were not able to consult maps in other institutions.

Korea, manuscript map, late nineteenth century, 74.5 × 71.4 cm (MARKK 12.24:46, collection Prof. Carl Gottsche, accession in 1912)

3. *Daedongyeojido* 大東輿地圖 ("Territorial Map of the Great East [Korea]")
Korea, manuscript map, after 1861, 23 map segments of different lengths, folded 29.7 × 19.8 cm (MARKK 33.215:16, collection Konsul H.C. Eduard Meyer, access 1933)
4. *Daedongyeojido* 大東輿地圖 ("Territorial Map of the Great East [Korea]")
Korea, hand-coloured woodblock print, 1861, 22 map segments of different lengths, folded 29.7 × 19.8 cm (MARKK 12.24:138 collection Prof. Carl Gottsche, accession in 1912)
5. *Dori-pyo* 道里標 (Tables showing the miles between provinces)
Korea, hand-coloured woodblock print, 1820s, 103 × 58 cm (MARKK 12. 24:39, collection Prof. Carl Gottsche, accession in 1912)
6. *Hwanghae-do* 黃海道 ("Map of Hwanghae Province")
Korea, manuscript map, end of eighteenth century, 109 × 123 cm (MARKK 12.24:52, collection Prof. Carl Gottsche, accession in 1912)
7. *Jeolla-do* 全羅道 ("Map of Jeolla Province")
Korea, manuscript map, early eighteenth century, 105 × 63 cm (MARKK XX SOAS 718, provenance and accession date unknown)
8. *Yeojido* 輿地圖 (hand atlas)
Korea, hand-coloured woodblock print, ca. 1880, folded: 27.1 × 16.5 cm, unfolded: 27.1 × 33 cm (MARKK 12.24:50, collection Prof. Carl Gottsche, accession in 1912)
9. *Yeojido* 輿地圖 (hand atlas)
Korea, manuscript map, late eighteenth century, folded: 22.5 × 17.9 cm, unfolded: 22.5 × 35.8 cm (MARKK 82.93:1, purchase from Klaus G. Rügge, Asian Art, in 1982)
10. *Cheonsang Yeolchabunyajido* 天象列次分野之圖 (celestial map)
Korea, manuscript map, nineteenth century, Ø 76.3 cm (MARKK 76.28:17, collection Gernot Prunner, purchased in Seoul, accession in 1976)
11. Geomancy map (untitled)
China, manuscript map, late nineteenth century, 63 × 90 cm (MARKK 85.48:2, purchase from Klaus G. Rügge, Asian Art, in 1985)
12. Bird's-eye view map of the city of Qingdao 青島
China, manuscript map (on cloth), ca. 1900, 89.5 × 174 cm (MARKK A 4375, purchase from Herman Gerlof in 1903)
13. *Puhe ting Guangxu ershiliu nian suixiu gongcheng ti gu tu* 捕河廳光緒貳拾陸年歲修工程題估圖 ("The Grand Canal embankment repair map for the sub-prefecture Puhe, in the year Guangxu 26 [1900]")

China, manuscript map, ca. 1900, 19 × 77 cm (MARKK 32.175:2341, collection Otto Samson, accession in 1932)

14. *Tianxia yutu* 天下輿圖 ("Map of all the lands under the Heavens")
    China, scroll with manuscript maps, early eighteenth century, 60 × 1500 cm, (MARKK 640:07, purchased by I.F.G. Umlauff in 1906, according to the seller "from the Imperial Palace in Beijing")
15. *Wutaishan sheng jing quan tu* 五臺山聖境全圖 ("Map of the sacred places of Wutaishan")
    China, manuscript map (on cloth), second half of nineteenth century, 88 × 196 cm (MARKK XX SOAS 408, purchased between 1900 and 1908, possibly looted from the Imperial Palace in Beijing)
16. Maps of Taiyuan 太原, untitled
    China, manuscript maps, late nineteenth century, five maps 37 × 39 cm (MARKK 32.175.2342–46, collection Otto Samson, accession in 1932)
17. *Biao xia li heshui shi taihu you ying xin zhang fan jing yutu* 標下裏河水師太湖右營新章汎境輿圖 ("Map of the LakeTai Right Battalion's Newly Established naval forces")
    China, manuscript map, 1871, 105 × 68 cm, (MPIWG 17–1878)[98]
18. *Shan hai guan di yu quan tu* 山海關地輿全圖 ("Map of Shanhaiguan")
    China, manuscript map (on silk), 52 × 91 cm, 1900 (MPIWG 17–1180)[99]
19. *Da Qing yi tong yu di quan tu* 大清一統與地全圖 (Set of Chinese provincial maps)
    China, 22 woodblock prints, some hand-coloured, different sizes, 1864 (MPIWG Rara D 212)[100]

On the maps we examined, cinnabar, lead red, and red ochre were often used for red; azurite, Prussian Blue, and indigo for blue; copper green and copper arsenite pigments (probably malachite and Paris green), copper chloride (atacamite), and organic compounds for green; while orpiment, yellow ochre, and organic dyes (probably gamboge) were used for yellow; lead white, shell white, and zinc white for white; and soot for black. In isolated cases, carmine was used for red and ultramarine for blue colourings. Our expectation that the same palette of colourants used for painting was also applied for map colouring was confirmed. In general, the colourants found on the maps we examined are consistent with the colourants listed and described in the consulted painting manuals and reports based on material scientific research.[101]

98 Online link: https://dlc.mpg.de/image/1035872633/1/.
99 Online link: https://dlc.mpg.de/image/1025141482/1/.
100 Online link: https://dlc.mpg.de/image/1030293198/1/.
101 See, for example, Yu 1988, Forbes 1932, Kogou et al. 2016, Nam et al. 2016, Yamasaki and Emoto 1979, Fitzhugh, Leona and Winter 2003.

Of course, it cannot be assumed that each kind of pigment came from only one single deposit. In some cases, however, a trace analysis can help determine the provenance of a mineral and thus connect it with a specific deposit. This was unfortunately not possible in our research project.[102] Considering the organic dyes, it becomes clear that the regional availability of raw materials determined the constituents of certain colourants. For example, only the trees of the genus Garcinia, from which gamboge is produced, are native to South and Southeast Asia. Although it is possible to make general statements about the colourants used for map colouring in East Asia from the material studied here, further investigations and, above all, the merging of case studies from other regions are necessary in order to be able to make more profound and comparative statements on this topic.

5.2.1 Red Colourants on East Asian Maps

The signal colour red is an immediate eye-catcher. It played an important role in East Asia in marking larger places on maps—using red signs or red framing. It was also used for denoting roads and highlighting details and decorative elements. In some cases, the colour red was employed for graphic elements like Chinese characters. Occasionally purple and pink tones were thinly applied on maps as well, for example to represent deserts on Chinese maps.

The presence of red pigments and dyes that were available when the investigated maps were made can be clearly established based on their characteristic absorption in the spectrum of visible light. The inorganic pigments vermilion or cinnabar, minium (lead red) and red ochre were identified on the basis of the marker elements they contain, usually heavy metals like mercury (Hg), lead (Pb), and iron (Fe) (Fig. 15). Cinnabar is a natural mineral, whereas minium is produced artificially and vermilion is an artificially made mineral, however, both cinnabar and vermilion are red mercuric sulfide compounds. Red ochre is a natural mineral pigment.

Evidence of cinnabar is unambiguous because cinnabar is the only known pigment consisting of a mercury compound. If mercury is detected by X-ray fluorescence analysis (Fig. 15), this is definite proof of cinnabar. Its unambiguous reflective behaviour in the visible spectrum of light (inflection point of the reflection curve at 590 nm, Fig. 16) and its clearly attributable Raman bands (δ(S-Hg-S)-deformation vibrations at 253 cm^{-1} and 286 cm^{-1} and symmetrical stretch vibrations ν(Hg-S) at 343 cm^{-1}) (Fig. 17) make it possible to unmistakably identify cinnabar with optical reflection or Raman spectroscopy.

102 Provenance analyses regarding deposit research require either a thicker layer of paint for non-invasive examination or sampling. Neither is given here.

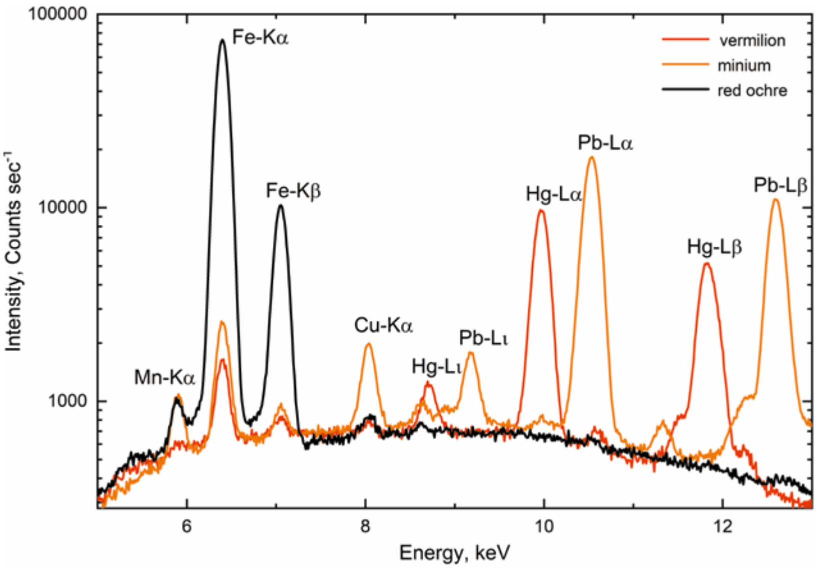


FIGURE 15 X-ray fluorescence spectra of the three 'classic' red pigments, vermilion (HgS), minium or lead red (Pb_3O_4), and red ochre (Fe_2O_3 with some MnO). The illustration makes it clear that, based on different electron transfers within the individual kinds of atoms, several characteristic peaks exist for one element. And in addition, as seen here, small amounts of Fe and Cu are often already present in the paper due to the production process.

Lead red is the only known red pigment that contains lead. However, VIS spectroscopy reaches its limits if the colourants are blends: mixtures with white or black pigments do not shift the inflection point, and are therefore not detectable with VIS spectroscopy. In addition, by means of XRF it is not possible to distinguish lead coming from lead red or from lead white. Further analytical methods such as X-Ray Diffraction (XRD) are necessary to separate the 'red' lead from the 'white' lead based on their cristal structures.

Another red colourant occasionally found on Chinese maps is carmine. This artificially produced organic dye can be positively identified due to its characteristic reflection spectrum. Conspicuous here are the three inflection points of the reflection curve at 490, 540, and 590 nm (Fig. 18).

The predominant red pigment on the maps examined in this study is cinnabar, which has been produced in China artificially and exported from there for centuries. It was found on 15 of the 19 maps.[103] It seems likely that this

103 We found cinnabar on the following maps: *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09); *Biao Xia li He Shui shi tai hu you ying xin zhang fan jing yu tu* 標下裏河水師太湖右營新章汛境輿圖, China,

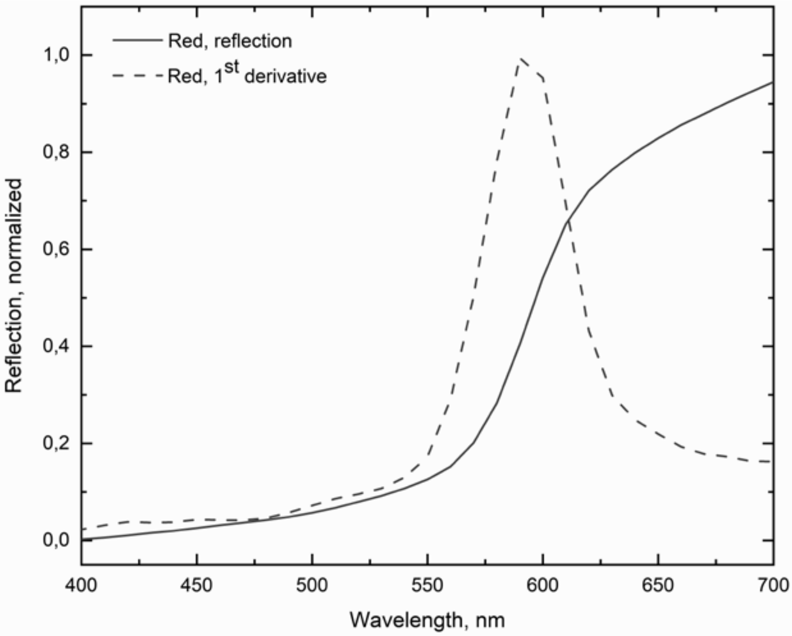


FIGURE 16 Reflection spectrum and associated derivation (to determine the inflection point) of the red colourant cinnabar on the Korean *Dori-pyo* 道里標 ("Tables Showing the Miles between Provinces"), from the 1820s (MARKK 12.24:39)

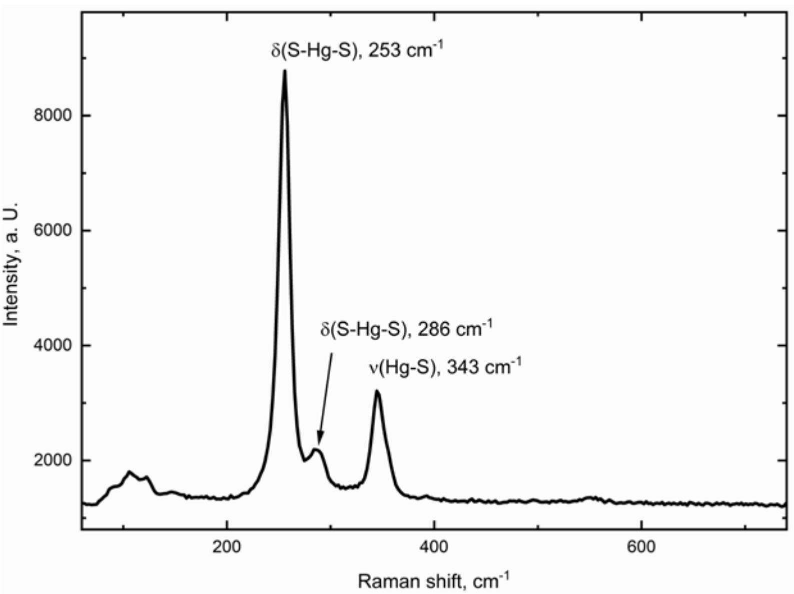


FIGURE 17 Raman shift of the red pigment cinnabar

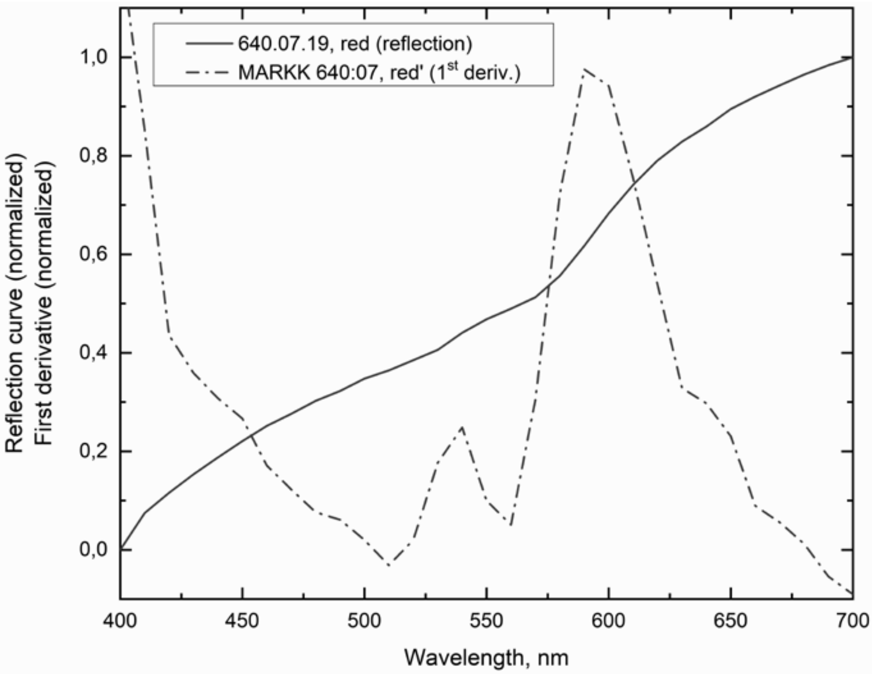


FIGURE 18 Reflection spectrum and associated first derivation of the dark red colourant on the Chinese map scroll *Tianxia yutu* 天下輿圖, Detail of Jiangnan Province (MARKK 640:07)

pigment came from the natural cinnabar deposits in the Southern Chinese provinces of Hunan, Guizhou, Sichuan and Yunnan (Yu 1988, 4–5, Golas 1999, 139). We found red and brown ochre on ten maps.[104] Red lead we identified on

1871 (MPIWG 17–1878); Bird's-eye view map of the city of Qingdao 青島, China, ca. 1900 (MARKK A 4375); *Cheonhado* 天下圖, Korea, late nineteenth century (MARKK 12.24:46); *Daedongyeojido* 大東輿地圖, Korea, after 1861 (MARKK 33.215:16); *Dori-pyo* 道里標, Korea, 1820s (MARKK 12.24:39); Geomancy map, China, late nineteenth century (MARKK 85.48:2); *Hwanghae-do* 黃海道, Korea, end of eighteenth century (MARKK 12.24:52); *Jeolla-do* 全羅道, Korea, early eighteenth century (MARKK XX SOAS 718); *Puhe ting Guangxu ershiliu nian suixiu gongcheng ti gu tu* 捕河廳光緒貳拾陸年歲修工程題估圖, China, ca. 1900 (MARKK 32.175:2341); *Shan hai guan di yu quan tu* 山海關地輿全圖, China, 1900 (MPIWG 17–1180); *Tianxia yutu* 天下輿圖, China, early eighteenth century (MARKK 640:07); *Wutaishan sheng jing quan tu* 五臺山聖境全圖, China, second half of nineteenth century (MARKK XX SOAS 408); *Yeojido* 輿地圖, Korea, ca. 1880 (MARKK 12.24:50); *Yeojido* 輿地圖, Korea, late eighteenth century (MARKK 82.93:1).

104 We found brown ochre on the following two maps: *Wutaishan sheng jing quan tu* 五臺山聖境全圖, China, second half of nineteenth century (MARKK XX SOAS 408), and the Maps of Taiyuan 太原, China, late nineteenth century (MARKK 32.175.2342–46). We found red ochre on the Bird's-eye view map of the city of Qingdao 青島, China, ca. 1900 (MARKK A 4375); *Puhe ting Guangxu ershiliu nian suixiu gongcheng ti gu tu* 捕河廳光緒貳拾陸

three maps.[105] Carmine was found only on two Chinese maps.[106] This colourant is obtained from scale insects native mostly to America (of the genus *Dactylopius*). Carmine-producing scale insects occurred in Asia only in peripheral areas (Central Asia and Mongolia) and apparently had little importance in producing colourants. Finding this colourant on a Chinese map may be an indication that the plant that hosts scale insects was also cultivated in Asia, or that the product may have been traded between America and Asia as early as the sixteenth century. According to Yu, carmine may have been imported to China as early as the sixteenth century (1988, 30).

5.2.2 Blue Colourants on East Asian Maps

Due to the widespread colour system of full-colouring the oceans (or at least the coastal area) and rivers on East Asian maps, the colour blue played an important role in the tinting of these bodies of water. In addition, blue was also used for the colouring of mountain ranges and for signs and the frames of cartouches. Occasionally, blue was employed for graphic elements and for decorative elements on maps.

We found blue colourants from different origins on the maps we examined. At the beginning of the eighteenth century, the innovative iron-based pigment Prussian Blue was invented in Europe. The formula did not remain a secret for long, and the pigment, which was cheap to make, rapidly spread throughout the world. It thus quickly replaced from the eighteenth century onwards the organic dye indigo for colouring rivers and bodies of water on East Asian maps. Expensive blue colourants such as ultramarine were also used in colouring maps but on a much lesser scale. However, by using only non-destructive analysis methods, it was not possible to distinguish between natural ultramarine obtained from lapis lazuli and artificial ultramarine produced since the nineteenth century. Cheaper local colourants such as azurite served for the colouring given to mountains on Chinese maps. In general, it can be stated

---

年歲修工程題估圖, China, ca. 1900 (MARKK 32.175:2341); *Cheonsang Yeolchabunyajido* 天象列次分野之圖, Korea, nineteenth century (MARKK 76.28:17); Geomancy map, China, late nineteenth century (MARKK 85.48:2); *Shan hai guan di yu quan tu* 山海關地輿全圖, China, 1900 (MPIWG 17–1180); *Da Qing yi tong yu di quan tu* 大清一統輿地全圖 China, 1864 (MPIWG Rara D 212); *Biao Xia li He Shui shi tai hu you ying xin zhang fan jing yu tu* 標下裏河水師太湖右營新章汎境輿圖, China, 1871 (MPIWG 17–1878).

105 We found red lead on the maps *Daedongyeojido* 大東輿地圖, Korea, 1861 (MARKK 12.24:138); *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half seventeenth century (MARKK 2917:09); and Maps of Taiyuan 太原, China, late nineteenth century (MARKK 32.175.2342–46).

106 We found carmine on *Tianxia yutu* 天下輿圖, China, early eighteenth century (MARKK 640:07) and *Biao Xia li He Shui shi tai hu you ying xin zhang fan jing yu tu* 標下裏河水師太湖右營新章汎境輿圖, China, 1871 (MPIWG 17–1878).

that for more translucent tinting of larger areas such as the colouring of seas indigo or Prussian blue were used, while for more opaque colouring such as the colouring of mountains or individual map elements most map makers gave preference to azurite or ultramarine.

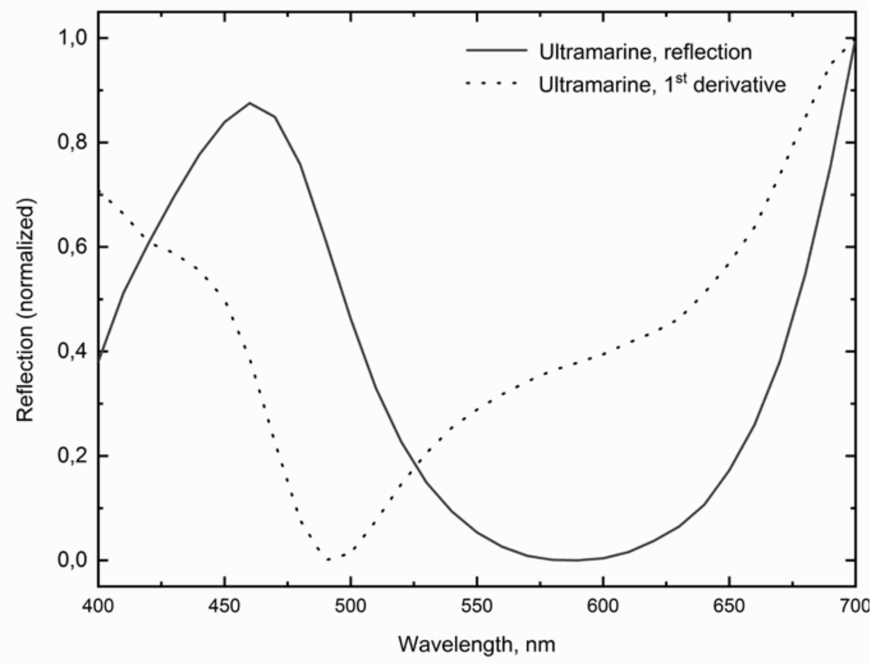
Using X-ray fluorescence analysis, blue colourants can be identified as the inorganic pigments azurite ($Cu_3(CO_3)_2(OH)_2$), Prussian Blue ($Fe_4[Fe(CN)_6]_3$), or ultramarine ($(Na_6Ca_2(Al_6Si_6O_{24})S_2$ based on their copper, iron, or silicon content respectively. The organic pigment indigo cannot be identified with X-ray fluorescence analysis. However, it is positively identified by its very characteristic reflection spectrum, which differs clearly from that of the other blue pigments. While, as expected, the blue pigments show the greatest reflection in the blue segment of the spectrum (ca. 430–500 nm)—this is shown in the example of ultramarine. Indigo presents different reflection behaviour (Figs. 19 and 20).

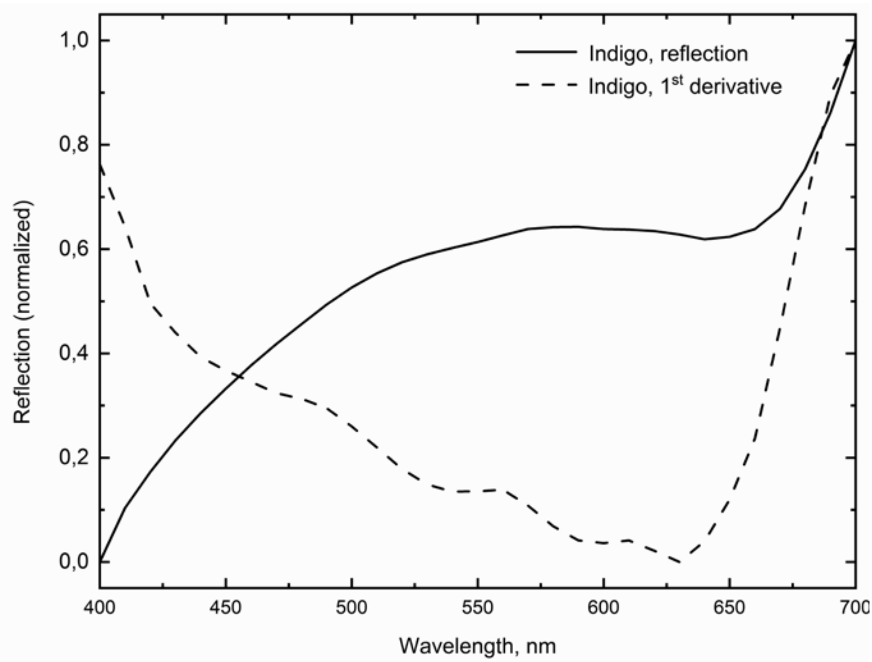
We found azurite in four maps.[107] Among the dyes, the blue colourant indigo, which was first used for the colouring of water areas on the maps, predominates. It was identified on nine of the maps from all three regions.[108] Indigo has been used throughout East Asia for many centuries. Originally obtained from Chinese indigo (also called Japanese indigo) (*Polygonum tinctorium*), which is native to the Far East, later it was increasingly obtained from plants of the *Indigofera genus* cultivated in India or Persia. Since the Tang Dynasty (618–907) at the latest, China imported this colourant (Fitzhugh, Leona and Winter 2003, 58). The blue pigment ultramarine is present on only two nineteenth-century Chinese maps: one of the pilgrimage site Wutaishan and another one of a coastal defence system.[109] As mentioned above, Prussian Blue entered the colourists' palette in the eighteenth century, it was found on

107 Azurite was detected in *Dori-pyo* 道里標, Korea, 1820s (MARKK 12.24:39); *Tianxia yutu* 天下輿圖, China, early eighteenth century (MARKK 640:07); *Hwanghae-do* 黄海道, Korea, end of eighteenth century (MARKK 12.24:52); *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09).

108 Indigo was found in *Dori-pyo* 道里標, Korea, 1820s (MARKK 12.24:39); *Hwanghae-do* 黄海道, Korea, end of eighteenth century (MARKK 12.24:52), *Yeojido* 輿地圖, Korea, late eighteenth century (MARKK 82.93:1); *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09); Geomancy map, China, late nineteenth century (MARKK 85.48:2); *Biao Xia li He Shui shi tai hu you ying xin zhang fan jing yu tu* 標下裏河水師太湖右營新章汛境輿圖, China, 1871 (MPIWG 17–1878); *Da Qing yi tong yu di quan tu* 大清一統與地全, 圖, China, 1864 (MPIWG Rara D 212); *Shan hai guan di yu 47 utu47u* 山海關地輿全圖, China, 1900 (MPIWG 17–1180); *Daedongyeojido* 大東輿地圖, Korea, 1861 (MARKK 12.24:138).

109 Ultramarine was found in *Wutaishan sheng jing 47 utu47u* 五臺山聖境全圖, China, second half of nineteenth century (MARKK XX SOAS 408); *Biao Xia li He Shui shi tai hu you ying xin zhang fan jing utu* 標下裏河水師太湖右營新章汛境輿圖, China, 1871 (MPIWG 17–1878).





FIGURES 19–20 VIS spectra of indigo and ultramarine (nineteenth-century geomancy map, (MARKK 85.48:2); Chinese pilgrimage map *Wutaishan sheng jing quan tu* 五臺山聖境全圖, (MARKK XX SOAS 408)).

eleven of the nineteen maps from China, Korea and Japan.[110] Up to now, there are few unambiguous sources about the first appearance of this Prussian Blue. According to Yu, 'western' or 'foreign' colours—such as Prussian Blue—had been imported to China from Europe, especially since the nineteenth century (1988, 30). Fitzhugh, Leona and Winter (2003, 5, 57) stated that it was imported to Japan after the late eighteenth century.

5.2.3 Yellow Colourants on East Asian Maps

Yellow also played an important role in map colouring in East Asia. As mentioned before, in the classical Chinese *wuxing* 五行 system four colours are associated with the four cardinal directions, while yellow represents the centre. On Korean maps, the districts of the province in which the capital (today's Seoul) is located are often shown as yellow circles. On Korean maps of the capital and its surroundings, the capital is also often coloured in yellow. The colour was also used for the colouring of signs and cartouches. Occasionally yellow was used to tint border lines, roads and routes. The Yellow River is also generally coloured yellow.

In East Asia, gamboge—a vegetable colourant obtained from the milky sap of a tree of the genus Garcinia (*Garcinia hanburyi*, *Garcinia gummi-gutta*, *Garcinia morella*, and others)—was often used for colouring. Native to South and Southeast Asia, gamboge was imported to East Asia (Yu 1988, 13). It was often mixed with indigo (and later with Prussian Blue) to produce green colours. In addition, the highly toxic pigment orpiment that contains arsenic was often used for colouring yellow elements on maps, particularly on Korean maps. Real gold was only occasionally used for certain decorative items on maps. For example, we identified gold on a nineteenth-century Chinese geomancy map showing the ideal position for a tomb for an older couple. Gold was

110 Prussian blue was found in *Daedongyeojido* 大東輿地圖, Korea, after 1861 (MARKK 33.215:16); *Dori-pyo* 道里標, Korea, 1820s (MARKK 12.24:39); *Jeolla-do* 全羅道, Korea, early eighteenth century (MARKK XX SOAS 718); *Yeojido* 輿地圖, Korea, ca. 1880 (MARKK 12.24:50); *Cheonhado* 天下圖, Korea, late nineteenth century (MARKK 12.24:46); *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09); Bird's-eye view map of the city of Qingdao 青島, China, ca. 1900 (MARKK A 4375); *Puhe ting Guangxu ershiliu nian suixiu gongcheng ti gu tu* 捕河廳光緒貳拾陸年歳修工程題估圖, China, ca. 1900 (MARKK 32.175:2341); Maps of Taiyuan 太原, China, late nineteenth century (MARKK 32.175.2342–46); *Cheonsang Yeolchabunyajido* 天象列次分野之圖, Korea, nineteenth century (MARKK 76.28:17); *Shan hai guan di yu quan tu* 山海關地輿全圖, China, 1900 (MPIWG 17–1180).

used to decorate their portrait shown on the map's upper part. Furthermore, we identified gold leaf used to decorate the frames of a Japanese map screen.[111]

Again, using X-ray fluorescence analysis to identify characteristic marker elements such as arsenic (orpiment) and iron (ochre) provides unequivocal evidence of the respective colourant (Fig. 21). Along with orpiment, there is another arsenic sulfide pigment: realgar. The two cannot be distinguished based on their elemental composition. However, slight differences in the colour of the two pigments (yellow orpiment and orange realgar) are easily detected with VIS spectroscopy.

Although gold foil and gold ink look yellow, they are not counted among the yellow pigments. The metal can be easily identified with X-ray fluorescence analysis. Auxiliary components, such as copper or zinc, with which the gold is alloyed, are often also found.

Along with the inorganic pigments, the organic colourant gamboge can be identified based on the characteristic VIS reflection spectra (Fig. 26a in Section 6, Case Studies). This analysis is not trivial, because an unambiguous categorization is possible only with an extensive reference databank. Regional plants, too, have often been used to produce yellow colourants. Lack of access to plants makes it harder for a fragmentary reference databank to provide a definitive identification.

The yellow-gold orpiment that was detected on six maps[112] might be extracted from areas in the provinces of Hunan, Gansu, and Yunnan. China's most important orpiment mines] during the Qing Dynasty (1644–1911) lay in the provinces of Sichuan, Yunnan and Guangxi (Yu 1988, 7, 9). Orpiment has been most probably in use as a pigment since the fourth century (Golas 1999, 176). Yellow ochre we only found on one Chinese map.[113] Organic yellow dyes, most probably gamboge, were recognized on six maps.[114]

---

111 Geomancy map, China, late nineteenth century (MARKK 85.48:2) and *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09).

112 We found yellow-gold orpiment in *Daedongyeojido* 大東輿地圖, Korea, after 1861 (MARKK 33.215:16); *Dori-pyo* 道里標, Korea, 1820s (MARKK 12.24:39); *Hwanghae-do* 黃海道, Korea, end of eighteenth century (MARKK 12.24:52); *Yeojido* 輿地圖, Korea, late eighteenth century (MARKK 82.93:1); *Wutaishan sheng jing quan tu* 五臺山聖境全圖, China, second half of nineteenth century (MARKK XX SOAS 408); Maps of Taiyuan 太原, China, late nineteenth century (MARKK 32.175.2342–46).

113 We found yellow ochre in *Puhe ting Guangxu ershiliu nian suixiu gongcheng ti gu tu* 捕河廳光緒貳拾陸年歲修工程題估圖, China, ca. 1900 (MARKK 32.175:2341).

114 Gamboge was detected in *Daedongyeojido* 大東輿地圖, Korea, 1861 (MARKK 12.24:138); *Daedongyeojido* 大東輿地圖, Korea, after 1861 (MARKK 33.215:16); *Tianxia yutu* 天下輿圖, China, early eighteenth century (MARKK 640:07); *Cheonhado* 天下圖, Korea, late

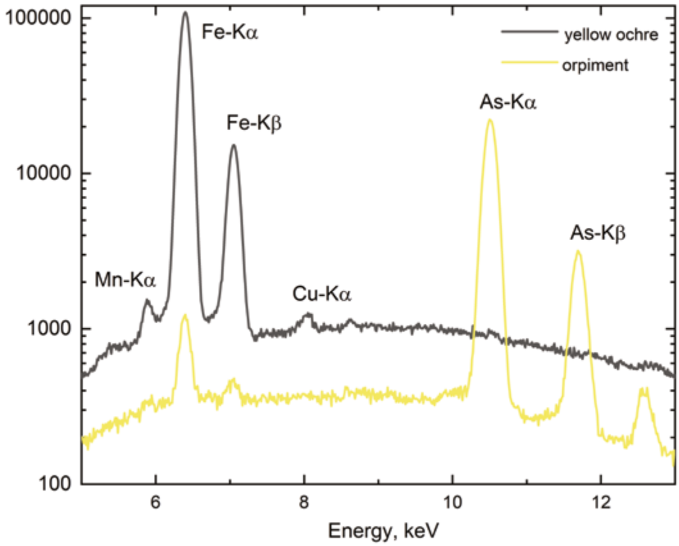


FIGURE 21 X-ray fluorescence spectra of two yellow pigments, orpiment (As_2S_3) and yellow ochre ($FeO(OH)$)

5.2.4 Green Colourants on East Asian Maps

After blue, green was often used to tint bodies of water and mountains. Green colourants were mostly copper-based and easy and cheap to produce. Minerals such as malachite were often used as green pigments in East Asia. In addition, it was common to use a mixture of blue and yellow to produce green, in particular a mixture of indigo and gamboge, orpiment and indigo, or orpiment and Prussian blue.[115]

Most inorganic green pigments are compounds of the element copper, basically carbonate, acetate, chloride, and hydroxide. X-ray fluorescence analysis only allows us to distinguish the compounds containing chlorine, for example atacamite, $Cu_2Cl(OH)_3$, from the others. Malachite (a copper carbonate, $Cu_3(CO_3)_2(OH)_2$), and Verdigris (a copper acetate of various compositions, for example $Cu(CH_3COO)_2 \times H_2O$) cannot be distinguished via XRF, because the elements carbon, oxygen, and hydrogen are not accessible.[116] In this case, X-ray diffraction would be helpful.[117]

nineteenth century (MARKK 12.24:46); *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09); Geomancy map, China, late nineteenth century (MARKK 85.48:2).

115 See also Fitzhugh, Leona and Winter 2003, 24.

116 Light elements cannot be detected with XRF under normal conditions (without vacuum).

117 X-ray diffraction is a suitable method to investigate crystalline samples (e.g., pigments). However, samples would have had to be taken. This was not possible.

The same is true for the copper arsenate pigments: these synthetic preparations, which were first produced at the beginning of the nineteenth century, can be distinguished by XRF from the aforementioned green copper pigments. However, the specific pigments, for example Paris green ($Cu(CH_3COO)_2 \times 3Cu(AsO_2)_2$) and Scheele's green ($CuHAsO_3$), can be best differentiated by the structure and size distribution of the grains of pigment; this, however, requires the transport of the object to the equipment, which is too large to move and, if necessary, taking a sample.

VIS spectroscopy is not an ideal method for distinguishing among copper-green pigments either, since the characteristic VIS spectra of a single kind of pigment can already differ greatly due to different production processes. This extensive range makes it impossible to distinguish individual copper-green pigments using this technology. As mentioned before, scientific methods of phase analysis such as X-ray diffractometry have been the usual methods of choice for differentiating copper green and copper arsenate pigments. However, due to the fragile state of preservation of most maps these methods, which require the transport of the object to the machine, cannot be implemented. The precise specification of the composition of green pigments was thus not possible within the framework of our research.

However, if we make use of the literature published up to now on analyzed colourants in Asia (Fitzhugh, Leona and Winter 2003, Forbes 1932, Kogou et al. 2016, Nam et al. 2016, Yamasaki and Emoto 1979, Yang, Lee and Yi 2021, Uyemura 1931) and in the colouring manuals (Yu 1988, Chao 1979), a tendency emerges regarding which colourants were used. Verdigris is considered to be one of the earliest synthetic Chinese pigments, but it seems to have had minor importance in the Asian sphere. This prior knowledge led us to assume the presence of malachite in the parts of the East Asian maps we studied that were coloured with copper-green pigments.

We found malachite on five maps.[118] Copper chloride, such as atacamite, was only found on one Korean map.[119] The green copper arsenate pigments—such as Paris green—invented in the early nineteenth century, were found on four maps.[120]

118 Malachite was found on *Tianxia yutu* 天下輿圖, China, early eighteenth century (MARKK 640:07); *Hwanghae-do* 黄海道, Korea, end of eighteenth century (MARKK 12.24:52); *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09); *Wutaishan sheng jing quan tu* 五臺山聖境全圖, China, second half of nineteenth century (MARKK XX SOAS 408); *Shan hai guan di yu quan tu* 山海關地輿全圖, China, 1900 (MPIWG 17–1180).

119 Copper chloride was found on *Daedongyeojido* 大東輿地圖, Korea, 1861 (MARKK 12.24:138)

120 Copper arsenite pigments were found on *Dori-pyo* 道里標, Korea, 1820s (MARKK 12.24:39); *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century

5.2.5 Black and White Colourants on East Asian Maps

Soot is the colourant used in Chinese ink, and there are numerous recipes for its production from pinewood or other raw materials (Yu 1988, 35–37). The various white colourants can be distinguished by the presence of the elements lead, zinc, and barium in lead white ($2PbCO_3 \times Pb(OH)_2$), zinc white (ZnO), and lithopone ($mBaSO_4 \times nZnS$) respectively (Fig. 22). The production of artificial lead white pigment has been known in China since at least the Qin and Han Dynasties (221 BCE to 220 CE).[121] We found it on eight maps.[122] Zinc white was first used in Europe in the late eighteenth century; we found this pigment,

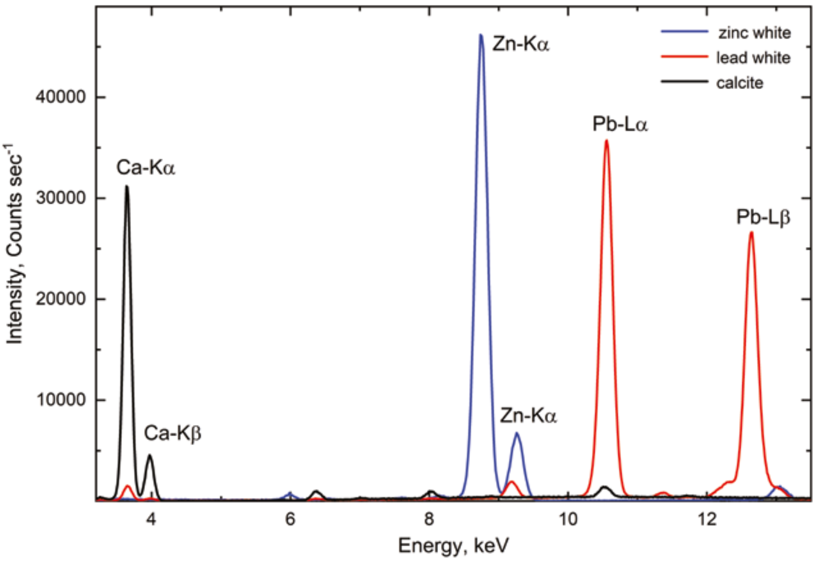


FIGURE 22 X-ray fluorescence spectra of three white pigments, zinc white (ZnO), lead white ($2PbCO_3 \times Pb(OH)_2$), and calcite ($CaCO_3$). The last one is often used as filler.

(MARKK 2917:09); *Wutaishan sheng jing quan tu* 五臺山聖境全圖, China, second half of nineteenth century (MARKK XX SOAS 408); *Biao Xia li He Shui shi tai hu you ying xin zhang fan jing yu tu* 標下裏河水師太湖右營新章汎境輿圖, China, 1871 (MPIWG 17–1878).

121 Needham 1976, 103.

122 Lead white pigment was found on *Daedongyeojido* 大東輿地圖, Korea, after 1861 (MARKK 33.215:16); *Dori-pyo* 道里標, Korea, 1820s (MARKK 12.24:39); *Jeolla-do* 全羅道, Korea, early eighteenth century (MARKK XX SOAS 718); *Hwanghae-do* 黃海道, Korea, end of eighteenth century (MARKK 12.24:52); *Wutaishan sheng jing quan tu* 五臺山聖境全圖, China, second half of nineteenth century (MARKK XX SOAS 408); Geomancy map, China, late nineteenth century (MARKK 85.48:2); *Da Qing yi tong yu di quan tu* 大清一統與地全圖, China, 1864 (MPIWG Rara D 212); *Biao Xia li He Shui shi tai hu you ying xin zhang fan jing yu tu* 標下裏河水師太湖右營新章汎境輿圖, China, 1871 (MPIWG 17–1878).

probably imported from Europe, on three East Asian maps.[123] The palette of the white colourants is completed with shell white (calcium carbonate, $CaCO_3$). We found it on one map from Japan.[124] This white pigment is made of crushed seashells, usually oyster shells. Shell white is unique to Japan where it was the common white that has been used by painters since the fifteenth century.[125] Thus it is not surprising that it was found on the examined Japanese map.

6 Shedding Light on Colours on Maps

Using selected maps from China, Korea and Japan in the MARKK collections, the following case studies will help to tell the history of colours on East Asian maps from the material science and cultural-historical point of view.

6.1 *The Chinese Map Scroll Tianxia yutu*

The map scroll discussed here has the format of a traditional Chinese handscroll or *shoujuan* 手卷 and contains 25 hand-drawn maps of the provinces of mainland China, its border areas and tributary states (Fig. 23). The maps were drawn up as part of one of the most comprehensive mapping projects in Chinese history, carried out by European and Chinese cartographers working in close collaboration (Cams 2017, Fuchs 1943). At the beginning of the eighteenth century, the Kangxi Emperor (r. 1661–1722) entrusted a group of Jesuit missionaries with the surveying and mapping of China and its outer borders. They carried out this task together with Qing officials, using new cartographic techniques based on triangulation. As a result of this cooperation, the first map series was printed from woodblocks in 1717, which became known as the *Kangxi huang yu quan lan tu* 康熙皇輿全覽圖 ("Maps for a Complete View of the August Empire of the Kangxi Era") or 'Kangxi Atlas'. The cartometric properties and cartographic conventions of the manuscript scroll of maps discussed here suggest that they are closely linked to the 'Kangxi Atlas'.[126]

123 Zinc white was found on *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, Japan, second half of seventeenth century (MARKK 2917:09); Bird's-eye view map of the city of Qingdao 青島, China, ca. 1900 (MARKK A 4375); Geomancy map, China, late nineteenth century (MARKK 85.48:2).

124 Shell white was found on *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, second half of seventeenth century (MARKK 2917:09).

125 Fitzhugh, Leona and Winter 2003, 5–6.

126 For comparable maps see the "Kangxi Atlas" (https://qingmaps.org/maps/kangxi-1721) and the 1721–22 *Huang yu quan lan fen sheng tu* 皇輿全覽分省圖 at the Library of Congress (shelfmark G2306.F7 H8 1722): http://hdl.loc.gov/loc.gmd/g7821fm.gct00232. This atlas was compiled in the context of the same cartographic project, the maps are

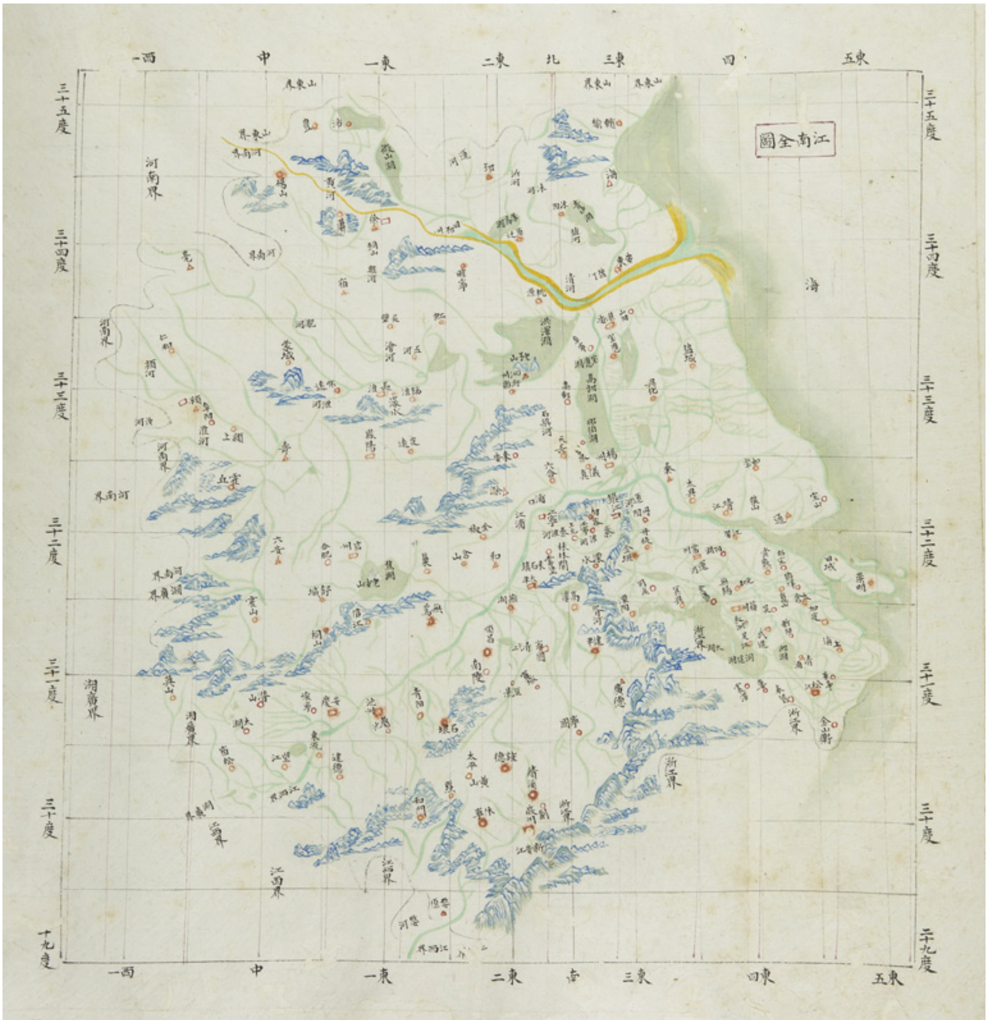


FIGURE 23 Detail of the map scroll *Tianxia yutu* 天下輿圖 ('Maps of [All] under Heaven') showing Jiangnan province in China. 60 × 1500 cm (entire scroll).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. 640:07

based on the same surveying and mapping process. Although the Kangxi atlas contains black-white woodblock-prints and the MARKK maps are hand-drawn and hand-coloured at first glance the two map sets correspond on several levels. If one places each pair of the same maps in the two sets on top of one another, the outlines of the depicted areas correspond nearly completely. This is also true for most of the river courses. On both map sets areas beyond the indicated provincial borders remain blank, they only contain the map titles as well as the names of bordering regions.

The dates of the maps are still a matter of discussion and no final statement on this issue can be made. The scroll does not contain a colophon or provide any information about its maker, place and date of production. All maps represent the administrative division and the language of the period before 1723 and thus they could be contemporary with, or perhaps predate, the printed 'Kangxi atlas' itself. On the other hand, many maps were copied and reprinted almost unchanged over a long period of time in China. This also happened with manuscript maps, which were produced and circulated in parallel alongside printed maps until the early twentieth century. Thus, the maps might also be made later in the eighteenth or nineteenth century.[127]

In contrast to the printed maps in the 'Kangxi atlas', which remained uncoloured, the manuscript maps in this scroll were coloured according to the typical colour system employed on East Asian maps over a long period of time, which can be observed on numerous Chinese province maps: the oceans (or at least the coastal area) and rivers were usually fully coloured in blue or green, while the land was left uncoloured. Only topographical elements, such as mountains, were coloured. On Chinese maps, place names were usually encoded using specific (coloured and uncoloured) signs to provide information about the size and configuration of local government as well as other important characteristics. This system was also applied on the map scroll considered here, yet no additional legend for the signs was provided by the mapmaker.

The mapmaker used black ink for all names of places, rivers and other topographical elements.[128] The names of the various provinces or frontier regions are framed with dark red rectangles. Mountains were coloured in blue, and rivers and the sea in green—except for the Yellow River on its course through several provinces. The Great Wall is shown as a black dotted line. Curiously, the European system of a grid of lines of longitude and latitude (in black) coexists with the traditional rectangular grid system customarily used in China (in dark red), in which Beijing is taken as the prime meridian. This choice of colours apparently followed the traditional practice in two-coloured Chinese atlases of printing the names of the current geographical territories in black and the historical place names in red. In this sense, the Chinese grid system drawn in red is regarded as the historical system, while the European longitude and latitude lines drawn in black are regarded as the more 'modern' one.

The red signs on the map were drawn with cinnabar and the blue mountains with azurite (Fig. 24). Two different pigments were used in the colouration of the water: whereas the rivers were drawn using a copper-green pigment

127 For a detailed discussion of the map scroll see Lange, forthcoming.

128 All of the maps in the scroll appear to be drawn by the same hand and labelled in the same handwriting. However, it is unclear if the same person did the drawing and writing.

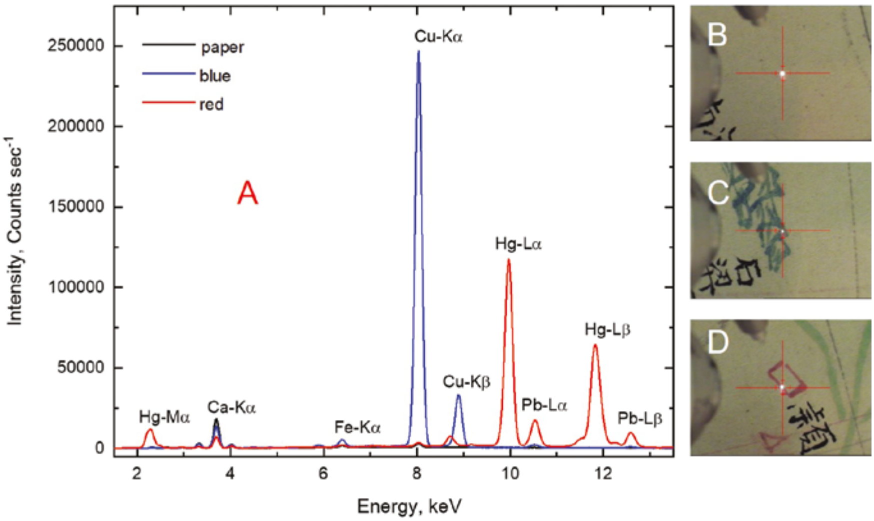


FIGURE 24 XRF spectra of the red and blue colourants used for the colouring of the mountains and signs in the map scroll *Tianxia yutu*. The presence of copper (Cu) in blue areas indicates the use of azurite. The pigment cinnabar that contains mercury (Hg) was used for red areas. The comparison with the spectrum of the background shows that elements calcium (Ca) and iron (Fe) result from the paper.

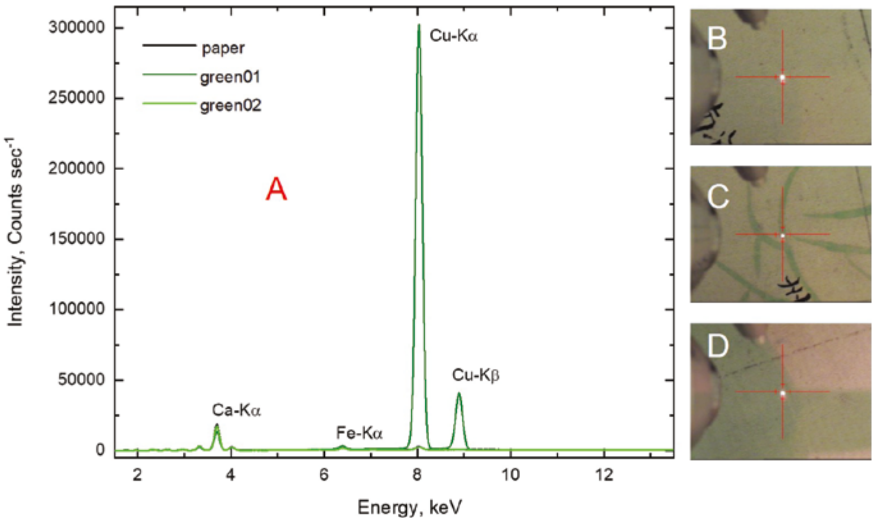
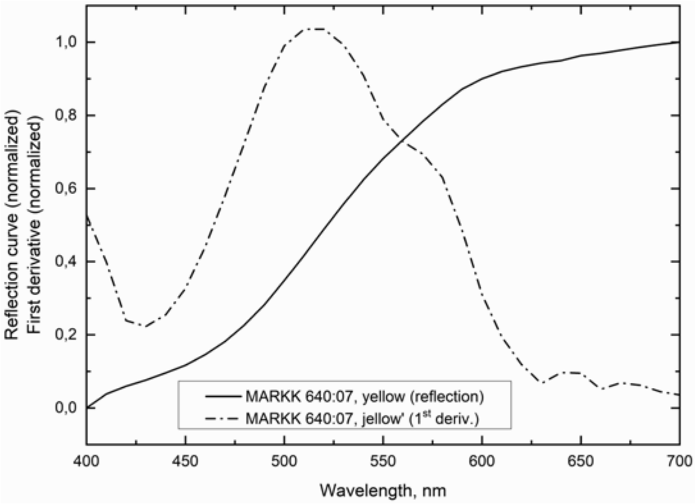
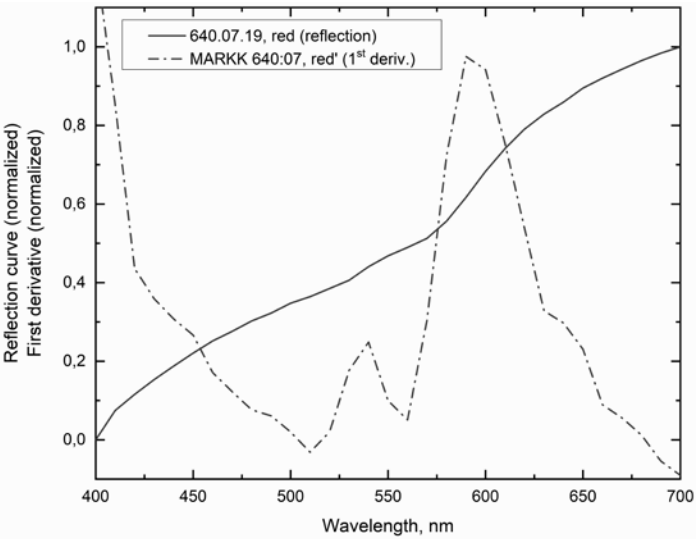


FIGURE 25 XRF spectra of the two green colourants used for the colouring of the rivers (green01) and the sea (green02). The presence of copper (Cu) in green01 indicates the use of malachite. The comparison of green02 with the spectrum of the background indicates an organic dye, since no characteristic element that indicates an inorganic compound could be detected.





FIGURES 26–27 VIS spectra with corresponding first derivatives of the yellow (top) and red organic dye (bottom). The comparison of the reflection curves (local minima and maxima, inflection points) with corresponding references allows the assignment of gamboge as a yellow dye and carmine as a red dye.

(possibly malachite), an organic pigment was used for the sea (probably a mix of gamboge and indigo, Fig. 25). The yellow colouring agent used for the Yellow River is also organic (probably gamboge, Fig. 26). The two map grids were drawn with red cochineal carmine and carbon black (soot). The dark red rectangular frames bordering the province names were also drawn with red cochineal carmine (Fig. 27).

The map scroll examined reveals in-depth knowledge of traditional Chinese cartography and is representative of many eighteenth-century Chinese maps. On the one hand, the maps have a mathematical foundation and make consistent use of signs. On the other hand, they show 'aesthetic' elements and colouring similar to that applied to many Chinese maps clearly influenced by traditional landscape painting. This is also valid for the use of colourants characteristic in this region and at that time, such as cinnabar, malachite, gamboge and azurite, which was replaced to a large extent by Prussian Blue in the nineteenth century.

6.2 *The Korean Daedongyeojido*

The *Daedongyeojido* is considered the most significant work of Korean cartography due to its unusual size, accuracy and practicability of use. The map is divided into 22 segments that cover 120 miles each, running from North to South, folded into equal-sized sheets so that they fit into a slipcase for easy transport. Placed one beneath the other, they give a complete view of the country and the offshore islands, spanning 6.7 m in height and 3.8 m in width. The mapmaker, the geographer and cartographer Kim Jeong-ho 金正浩 (*c.*1804–1866), drew up a whole series of important maps, of which *Daedongyeojido* is regarded as his masterpiece. The map represents the zenith of Korean cartography before it was supplanted by European cartographic methods.[129]

There are two examples of *Daedongyeojido* in the collections of the MARKK—one hand-coloured woodblock print (Fig. 28) and a manuscript version (Fig. 29). Four colours were used in colouring both maps: red, blue, yellow and green. It was hoped that an analysis of the colourants used in colouring these two map sets could give a hint if they were made in the same workshop or at different places.

The colour scheme of both map sets followed the typical East Asian colouring system: water being coloured entirely in blue and land masses left uncoloured. Geomancy was a strong influence on traditional Korean cartography and mountain ranges run as the 'veins' of cosmic energy streams in uninterrupted

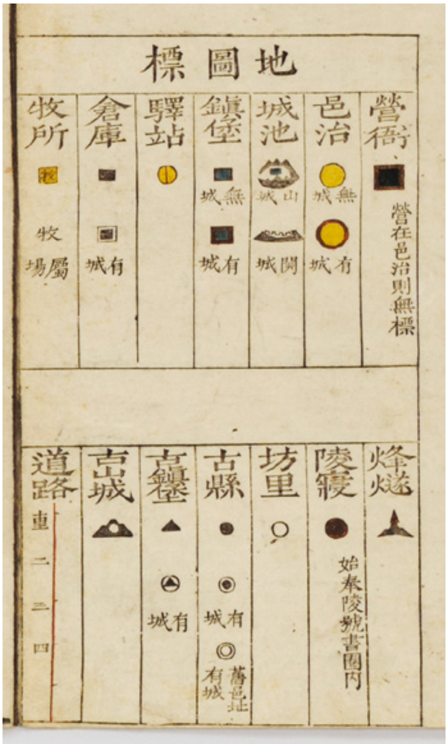
129 For further and more detailed information on the *Daedongyeojido* see Jang 2006, and the book *Kim Jeong-ho and his Daedongnyeojido, Territorial Map of the Great East*, published by the National Museum of Korea in 2007.

FIGURE 28 Detail of a printed and hand-coloured *Daedongyeojido* 大東輿地圖 ("Territorial Map of the Great East [Korea]"), 22 map segments of different lenghts, 29,7 × 19,8 cm (folded).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 12.24:138

FIGURE 29 Detail of the manuscript *Daedongyeojido* 大東輿地圖. 23 map segments of different lenghts, 29,7 × 19,8 cm (folded).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG/NRICH, INV. NR. 33.215:16.

chains through the entire length of the country. On the *Daedongyeojido* they are depicted largely in stereotypical form, with important mountains being larger and coloured green on the manuscript maps. Many of both the manuscript maps and the printed copies were coloured individually. As a result, the maps differ greatly in their appearance.

The information on the maps is conveyed through a combination of signs and colour coding. The legends appended to the map sets (Figs. 30 and 31), for instance, give the signs for administrative centres, garrisons, signalling beacons, and grain storehouses. The maps contain a comprehensive network of roads and ferry routes to the important offshore islands. The administrative jurisdiction to which the islands belong is shown by their inclusion within

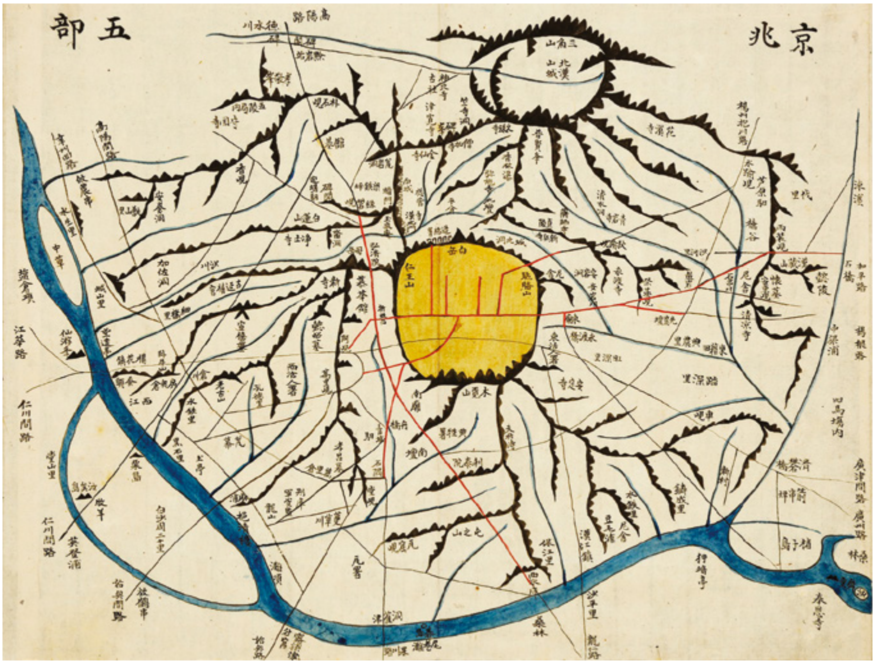


FIGURES 30–31 The legends for the signs used on the two map sets with different colourings: printed (left) and manuscript (right).

the dotted lines demarcating the borders of a district (shown in yellow on the manuscript map). On both the printed and manuscript maps, names encircled with a red line are district capitals, and double lines denote walled cities. In the printed version, the interior of the circles is coloured yellow. Squares with red perimeters show military garrisons, and triangular red flame signs represent signalling beacons.

Both *Daedongyeojido* sets contain city maps of Hanyang, today's Seoul (*Doseongdo* 都城圖, Figs. 32 and 33) and maps of the surrounding area outside the city walls (*Gyeongjo obudo* 京五部圖, Figs. 34 and 35). The type of colouring varies in several places: the mountain ranges surrounding Seoul are consistently shown on the printed city map in light green, while several different shades of green are used on the hand-drawn map. On the printed map of the environs of Seoul the mountain ranges, printed in black, were then painted over in green, while in the manuscript map they were consistently drawn in black ink. In the printed map set, roads are depicted by red lines. In contrast, on the hand-drawn map, both red and black lines denote roads. Waterways are shown on both sets in blue, in particular the Han River, which flows in the

FIGURES 32–33 *Doseongdo* 都城圖 ("Map of the walled capital") from the printed (top) and the manuscript *Daedongyeojido* (bottom). 30 × 40 cm.



FIGURES 34–35 *Gyeongjo obudo* 京五部圖 ("Map of the five administrative districts of the capital"), from the printed (top) and the manuscript *Daedongyeojido* (bottom). 30 × 40 cm.

south of the city. The royal capital is represented as a yellow area in the centre of the map of the surroundings. The choice of this colour is reminiscent of multi-coloured maps of the provinces of Korea, on which the colour yellow was chosen for the centre with the capital, in keeping with the traditional East Asian system of colours associated with the cardinal directions. The palace precincts and important cultic sites on the city map of Hanyang are similarly coloured yellow and given a red outline. Both maps of Seoul contain numerous captions, whereas on the printed map the administrative districts (*bang* 坊) are additionally shown as blue cartouches.

Different pigments were used in colouring these two map sets, which suggests that they were likely coloured at different times and/or in different places. The woodblock print was coloured using lead red, a yellow organic pigment (probably gamboge), blue indigo and a copper-green pigment (since chlorine is present, it could be atacamite). In the manuscript map, by contrast, cinnabar, yellow orpiment (with faint traces of cinnabar), as well as Prussian Blue blended with lead white were identified. The green-coloured elements were coloured using a mixture of Prussian Blue and an organic yellow colourant.

The colourants and the use of colours appear in many eighteenth- and nineteenth-century Korean maps, which indicates that they were characteristic for map making in that region and at this time.

6.3 *The Japanese Bankoku sōzu Jinbutsuzu*

This Japanese folding screen consisted of two panels decorated with a *Bankoku sōzu Jinbutsuzu*, a 'map of all lands and peoples' (Figs. 36 and 37), made by unknown cartographers.[130] The 'map of all lands and peoples' is based on the famous world map of the Jesuit Matteo Ricci (1552–1610), who was active in China, and attests to Japan's interest in the outside world before the Japanese government sealed off the country in 1639. 'Western' knowledge was brought to China by Jesuit missionaries in the sixteenth century and came to Japan from there.

In 1602 Ricci, together with Chinese translators and officials, drew up the world map *Kun yu wanguo quan tu* 坤輿萬國全圖 ("Map of the myriad countries of the world"), placing China at the centre of the map. European cartographic methods and Ricci's map had influenced Japanese map-making since

130 The map examined is the only Japanese manuscript map in the collection of East Asian maps at the MARKK. In contrast, the collection includes numerous colour-printed Japanese maps from the nineteenth century. Taking into consideration that the successful production of colour-printed maps in Japan led to a steep decline in the hand colouring of maps from the eighteenth century on, this is not surprising.

FIGURES 36–37 Japanese manuscript map titled *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図 ("Map of all lands and peoples"), 78 × 149 cm (each panel).
© MUSEUM AM ROTHENBAUM (MARKK), HAMBURG, INV. NR. 2917:09

the late sixteenth century. Japanese world maps made in the seventeenth century and based on European models belonged to the category of so-called Nanban world maps—derived from the term *nanbanjin* 南蛮人 ("southern barbarians"). This referred mainly to the Portuguese and Spaniards, who reached Japan coming from the South. The world map shown here, *Bankoku sōzu Jinbutsuzu* 萬國総圖人物図, was first printed in Nagasaki in Japan in 1645 and similarly designed in a format suited for use as decoration.[131] Whereas the first versions of *Bankoku sōzu Jinbutsuzu* were produced using woodblock printing techniques and subsequently hand-coloured, the example shown here is a manuscript map. The depiction of the continents as well as the designation of China as 'The Great Ming Empire' suggests on the one hand dating the map to the seventeenth century—probably before 1644—while on the other hand China was still usually referred to as 'The Great Ming Empire' in Japan even after the founding of the Qing Dynasty in 1644, so it is not possible to use this toponym to date the map securely.

The right-hand side of the screen shows the world map oriented to the East. The various regions were differently coloured and annotated in black ink. Borders and the outlines of the different countries are coloured in red and black. The equator is shown as a white and black dotted line outlined in red. Lines of longitude and latitude are drawn in black ink, while the tropics are in red. Pictures of ships from Japan, China, the Netherlands, and Portugal can be seen in the four corners of the map.

The left-hand part of the screen bears illustrations of forty ethnic groups with descriptive texts. Later versions of this type of map were printed in 1651, 1652, 1667, and 1671.[132] By comparing the map shown here with the several versions, we might assume that this one is based on that of 1645 and is one of very few known manuscript versions.

In the original colouration of the folding screen, lead red and cinnabar were identified as red pigments, and calcium carbonate or shell white as the white pigment. Blue areas were coloured with indigo or azurite, while copper green (probably malachite) was used for green ones. The yellow colourant was an organic dye. The frames of the two screens are decorated with gold leaf.

131 For comparable maps, see the late seventeenth-century *Bankoku sōzu* manuscript map at the University of British Columbia Library. Rare Books and Special Collections (G3200 1645z .S5; G3200_1645z_S5): https://open.library.ubc.ca/collections/tokugawa/items/1.0213137#p1z-, and the 1645 hand-coloured woodblock print *Bankoku sōzu Jinbutsuzu* in the Hiroshima Prefectural Museum of History (shelfmark 222): http://jmapps.ne.jp/hrsmkrh/det.html?data_id=15168.

132 For further and more detailed information on the *Bankoku sōzu* see Papelitzky 2014. For a detailed description of the map held in the MARKK, see Hagen 1928.

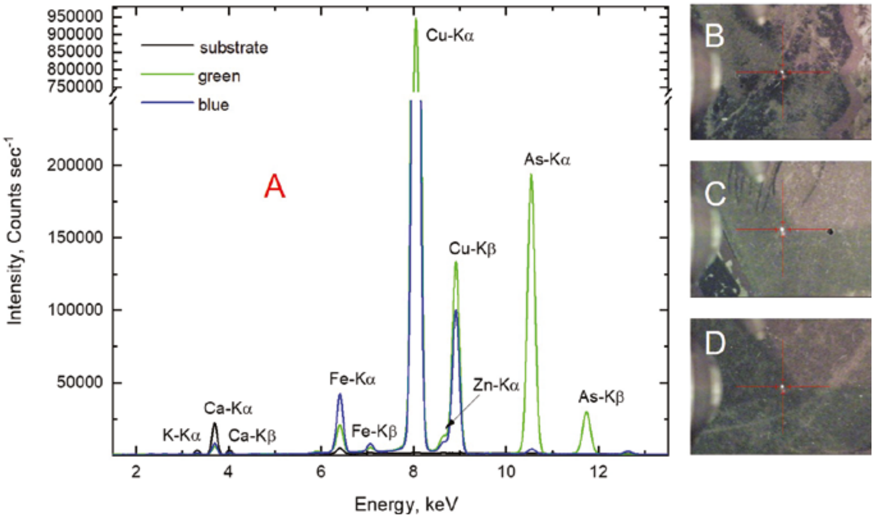


FIGURE 38 XRF spectra of the pigments that may have been added while overpainting. The green pigment, which contains copper (Cu) and arsenic (As), is possibly Schweinfurt green. It also contains zinc white (Zn). The spectrum of a blue area shows iron (Fe) and copper (Cu). Here we may conclude that the original painting with azurite was possibly painted over with Prussian Blue.

This colour palette is almost identical to the pigments identified by Fitzhugh, Leona and Winter (2003, 2) in Japanese paintings from the late sixteenth to mid-nineteenth century, who list shell white, vermilion, red lead, indigo, yellow earth, organic red, organic yellow, malachite, azurite, red and brown earths and organic brown.

The initial results from the screen revealed synthetic pigments, which would suggest that the object should be dated to a later time than the seventeenth century. However, some indices—still under consideration—may indicate that Prussian Blue, zinc white and a green copper arsenite pigment (possibly Paris green) were applied during later restoration work (Fig. 38). We assume that the screen was indeed produced in the seventeenth century but restored later, probably in the nineteenth century.

7 Conclusion

For three years we intensively studied colours on East Asian maps in Hamburg and Berlin, with a focus on maps made between the seventeenth and early twentieth century. But doing so we not only wanted to carry out research 'about' maps but above all to 'grasp' the maps in their materiality. Our aims to explore (1) the meaning and use of colours on East Asian maps, and (2) the scientific analysis of the colourants used on these maps were achieved by an interdisciplinary approach through a close collaboration between the humanities and natural sciences. The first goal was realized by the intensive, systematic and comparative examination of the colouring of numerous maps from China, Japan and Korea. From selected but representative examples, this book offers a general overview of map-colouring practices and the meaning of colours on maps in East Asia. To achieve the second goal, we undertook material scientific studies on hand-coloured maps from two collections in Hamburg and Berlin, and compared our results with the outcomes of similar scientific research on colourants and also with various textual sources such as manuals describing the production of pigments for painting. Although the number of maps for which we have undertaken a material examination was limited, our broad research approach allowed us to make some first basic statements about the colourants used to colour maps in East Asia.

Summarizing the results: printed maps were not hand-coloured frequently in East Asia. Furthermore, manuscript maps were produced for a broad range of users over a long period in parallel with printed maps. This is probably one of the causes that explain why no professional map colourists existed in East Asia, and the colouring of manuscript maps was in all likelihood done by those who had drawn the maps. The steep decline in hand colouring activity had already set in in Japan from the eighteenth century, due to the successful establishment of the market for prints with printed colour. Typical practices in map colouring could be identified for East Asian maps regarding their colour styles and colour schemes. In all three regions, colours in combination with signs were used to code information on maps. Legends or colour keys are rare on East Asian maps. This is probably because it was customary to colour manuscript maps by hand in East Asia for centuries, so colouring and colour coding practices had become consolidated and were already taken for granted.

The material scientific investigations showed that the colourants used in colouring maps were mostly the same as those used for painting in these regions. Since the material scientific analysis of the colourants was carried out using exclusively non-destructive methods, which preserved the materials under examination, but imposed restrictions on the findings, it was possible to distinguish mineral and plant-based colours and to narrow down their identifications, but not to draw conclusions as to the regions the colourants came from. It is probable that mineral and plant-based colourants were predominantly obtained locally in East Asia, with the additional use of colourants from the intercontinental trade. From the material analysis carried out in this project, it was found that new synthetic colourants from Europe were swiftly and thoroughly assimilated in East Asia, especially from the nineteenth century onwards. As regards the colouring systems of maps, we found only minimal influences from Europe on East Asia, mainly limited to an increase in the functional full colouring in of land masses from the nineteenth century on.

Colours made the maps, colours affected the maps' materiality, content and handling. Understanding the process of colouring maps is essential for the study of their material nature and their production as well as for the social, geographical and political context in which they were made. Map colouring provides an insight into past societies, landscapes and territories. Further research is essential, in particular comparative studies on maps from other regions in Asia, such as South, Southeast and Central Asia. In addition, material analyses of colour prints should be conducted in order to be able to make comparative statements about the colourants used for printing and hand-colouring and the associated colouring techniques. These would be challenging and worthwhile undertakings to gain a more comprehensive insight into the relation between maps and colours.

Acknowledgements

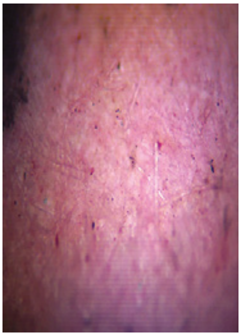
We would like to thank all our colleagues involved in this project for their generous support during the course of the project, namely Kathrin Enzel and Benjamin van der Linde (Hanseatic Business Foundation), Michael Friedrich and Eva Jungbluth (Centre for the Study of Manuscript Cultures of the Universität Hamburg), Susanne Knödel (MARKK), Jochen Schlüter (Mineralogical Museum/CeNak of the Universität Hamburg), and in particular Peter Zietlow who undertook the material scientific investigations of the maps. We owe further thanks to our student assistants, namely Sarah Brühl, Megan Müller, Alina Christiaans, and Christof Thiel.

Above all, we thank the Federal Ministry of Education and Research/Bundesministerium für Bildung und Forschung (BMBF) for funding the project "Coloured maps" and this publication.

Appendix: Non-invasive Techniques

Microscopy

The use of a visible light microscope gives information on the main characteristics of maps' materiality, for example, differences between paper and textile, details of colouring technology, and damage or overpainting, as well as



FIGURES 39–40
Microphotograph, 50× magnification, of the pigment cinnabar (vermilion, left) and the dye carmine (carmine, right). The pigment lies as an opaque layer on the surface of the paper, while the dye soaks into the paper matrix.

soluble dyes and insoluble pigments used in the maps (Figs. 39 and 40). With UV or IR light, the characteristic interaction, i.e., the absorption and reflection of the radiation, provides initial knowledge about the map's material characteristics—for example, black writing and drawing materials such as carbon inks and iron gall inks can be distinguished from each other.[133]

X-Ray Fluorescence Analysis

X-ray fluorescence (XRF) analysis is one of the classic methods for investigating the elements of inorganic-based pigments (Fig. 41). X-ray fluorescence is an atomic process in which an excited atom returns to its ground state by emitting radiation. The excitation of the atom as well as the fluorescence emission takes place in the range of X-rays. At the beginning of the process, the incident beam interacts with the electron shell of the atom: one electron from an inner shell is removed. In a second step, one electron from a higher energy level takes the place of the knocked-out electron. The energy difference between the two states is emitted as X-ray radiation. Since only very specific electron transitions are possible for a certain element, the excited element can be identified from the energy distribution of the characteristic X-ray fluorescence radiation.

The name for this radiation considers both the original site of the primary electron that was knocked out of its shell (K, L, M shell) and the ensuing relaxation process that fills the gap with additional electrons (α, electron from the next higher shell; β, electron from two shells higher; thus, Kβ, etc.). The height of the X-ray peak achieved makes it possible to deduce how much of the element is contained.[134]

133 Carbon inks absorb in the near infrared range while iron gall inks loose opacity. In addition, the tannins within iron gall inks absorb UV light.

134 Analyses were carried out on site with the mobile energy-dispersive micro-X-ray spectrometer ArtTAX® (Bruker Nano GmbH, Berlin, Germany, fig. 8–2), which consists of an air-cooled, low-power molybdenum tube (1), poly-capillary X-ray optics (measuring spot size 70 µm diameter) (2), an electro-thermally cooled Xflash detector (3), and a CCD

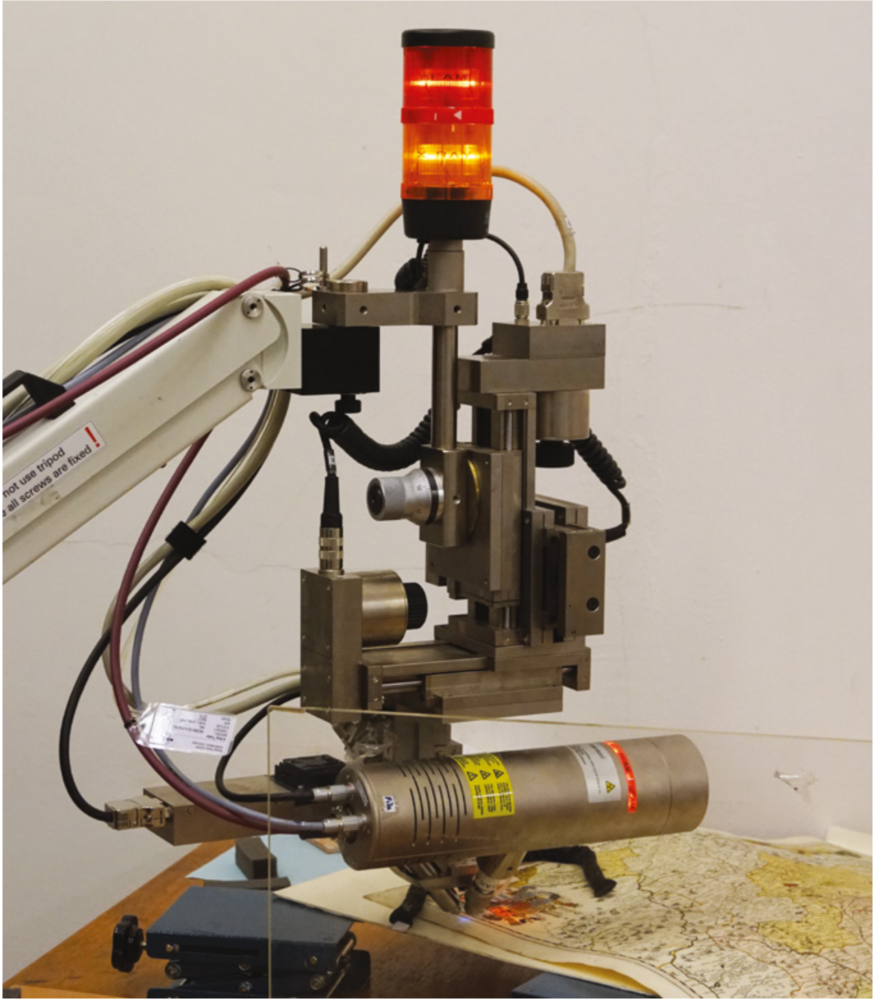


FIGURE 41 X-ray fluorescence analysis Bruker ARTAX

Vibrational Spectroscopy

Infrared spectroscopy and Raman spectroscopy, used as two complementary methods for the identification of molecules, are based on the interaction between electromagnetic radiation and chemical bonds. When infrared

camera for sample positioning. In addition, open helium purging in the excitation and detection paths widens the range of detectable elements without vacuum to z > 11. All measurements were made using a 30W low-power Mo tube, 50 kV, 600 µA, and an acquisition time of 15 s (live time) to minimize the risk of damage. For better statistics, we performed line-scan measurements; after measurement, at least ten individual measurements were averaged for one data point.

FIGURE 42 FTIR Spectroscopy in diffuse mode (DRIFTS) ExoScan spectrometer (A2 Technologies)

light or laser light hits chemical bonds, energy transfer can occur. This transfer depends on the energy of the irradiated light and the type of chemical bond. In contrast to the X-ray fluorescence analysis mentioned above, vibrational spectroscopic methods are chemical analysis methods.

Infrared spectroscopy is one of the classic methods of examining organic materials, for example, organic dyes or binding agents, but it is subject to some limitations. If complex mixtures of various binding agents are examined, auxiliary components and especially admixtures present only in traces can not be detected.

Infrared spectroscopy provokes a change in the vibrational or rotational state of the bonds. Since the amounts of energy necessary to achieve this are characteristic of the respective bonds, this permits the structure of the chemical bonds to be determined. The term infrared spectroscopy is often given additional attributes, such as in 'diffuse reflection' (Fig. 42), in 'attenuated total reflection', or in 'transmission'. These different measurement setups designate the path of the exciting infrared radiation when it hits the sample. Under varying lighting directions, different results can be expected. If no samples may be taken, 'diffuse reflection' is used as measurement mode. A comparison with a reference database allows the identification of materials.

When molecules are irradiated with monochromatic light, the irradiated light is scattered. When analysing the scattered light, in addition to the intensive primary line of the light source, additional spectral lines appear that are shifted at a characteristic distance from the frequency of the light source. These lines are called 'Raman shifts'. The Raman effect is based on another characteristic interaction between irradiated light and matter: molecules and molecular lattices always perform oscillations. The interaction of light with molecules and molecular lattices can be regarded as a collision process. In this impact process, energy is transferred between the radiated light and the molecules. Raman spectroscopy is used as a non-invasive analysis method in the field of pigment and mineral analysis (Fig. 43).[135]

VIS Spectroscopy

VIS spectroscopy is another technique that allows the identification of some colourants. Strictly speaking, VIS spectroscopy can be only applied to coloured or "chromatic" substances. "Achromatic" colours, like black, white, and grey, cannot be analyzed with this technique. If visible light interacts with a coloured body, the latter absorbs specific parts of the incident light and reflects others. The reflection curve thereby attained, which reveals the correlation of the reflected light as a function of the illuminating wavelengths of the excitation rays, is a little different for every colourant, which can thus be distinguished by subsequent mathematical methods (Fig. 44). This is feasible when determining the mineral pigments and organic dyes used until the end of the eighteenth century. But this method is not conclusive for many colourants from

135 In-situ Raman measurements were performed on a portable i-Raman®Plus spectrometer (B&W Tek Inc.) equipped with a 785 nm diode laser, a handheld fibre-optic probe, and a CCD detector. The probe was connected to a microscope head (Olympus 50× objective; BAC151B, B&W Tek Inc.), fixed on the motorized xyz stage of a tripod. The recorded spectra range from 100 to 3300 cm^{-1} (spectral resolution 4 cm^{-1}) with varying acquisition parameters of 5–120 s and 1–20% laser power.

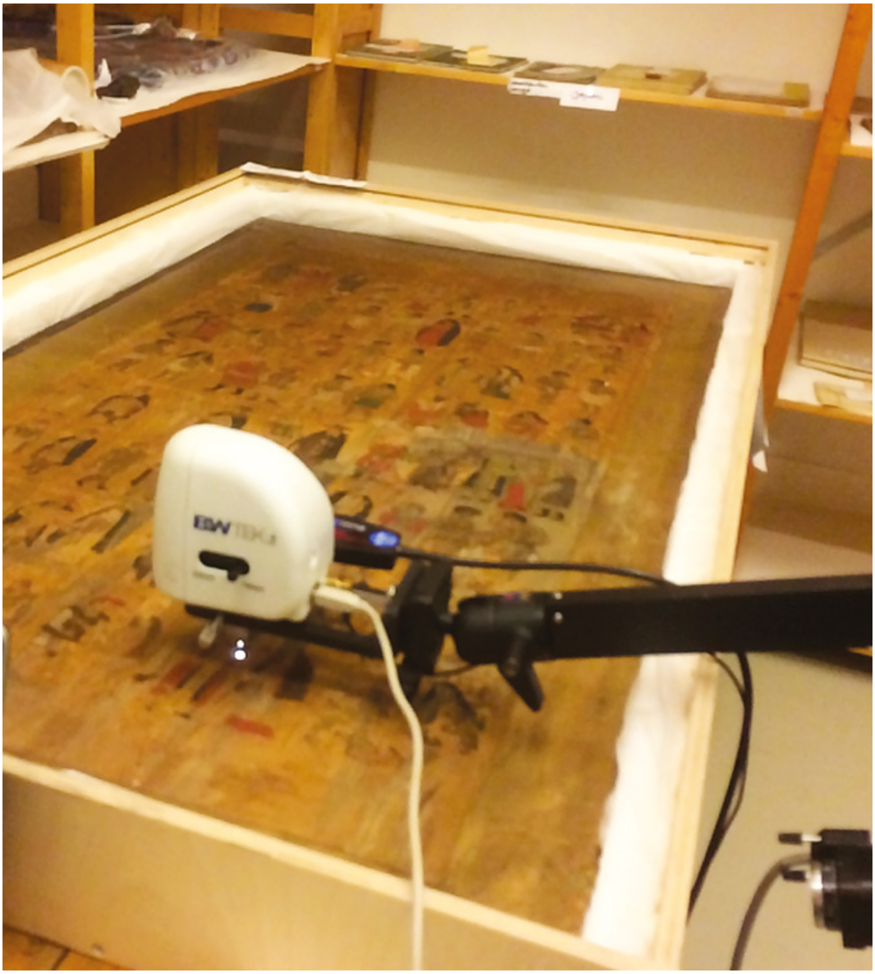


FIGURE 43 Raman spectrometer B&W Tek i-Raman plus

the nineteenth century. The reflectance curves of these synthetic pigments are very similar and therefore cannot be distinguished.[136]

136 The VIS spectrometer X-rite exact, with a spectral resolution of 10 nm and a range from 400 to 700 nm, was used for the analyses. A white reference tile is integrated into the spectrometer; it calibrates automatically and thus ensures optimal measuring accuracy. The aperture is 2.3 mm. The spectral deviation is calculated as 10 nm.

FIGURE 44 VIS spectrometer X-rite exact

Bibliography

Akin, Alexander. 2019. "Cartography." In *The Making of the Human Sciences in China. Historical and Conceptual Foundations*, edited by Howard Chiang, 52–69. Leiden, Boston: Brill.

Akin, Alexander. 2021. *East Asian Cartographic Print Culture. The Late Ming Publishing Boom and its Trans-Regional Connection*. Amsterdam: Amsterdam University Press.

Beijing daxue tushuguan 北京大学图书馆. 2008. *Huang yu xia lan: Beijing daxue tushu guancang qing dai caihui ditu* 皇與遐览: 北京大学图书馆藏清代彩绘地图 ("The Imperial Court: Painted Maps of the Qing Dynasty in the Library of the Bejing University"). Beijing: Zhongguo renmin daxue chuban she.

Berry, Mary Elizabeth. 2006. *Japan in Print. Information and Nation in the Early Modern Period*. Berkeley and Los Angeles: University of California Press.

Brokaw, Cynthia J. 2005. "On the History of the Book in China." In *Printing and Book Culture in Late Imperial China*, edited by Cynthia J. Brokaw and Kai-wing Chou, 3–54. Berkely: University of California Press.

Brokaw, Cynthia. 2010. "Commercial Woodblock Publishing in the Qing (1644–1911) and the Transition to Modern Print Technology." In *From Woodblocks to the Internet. Chinese Publishing and Print Culture in Transition, circa 1800 to 2008*, edited by Cynthia Brokaw and Christopher A. Reed, 39–58. Leiden and Boston: Brill.

Brokaw, Cynthia J., and Kai-wing Chou (eds.). 2005. *Printing and Book Culture in Late Imperial China*. Berkely: University of California Press.

Brokaw, Cynthia and Christopher A. Reed (eds.). 2010. *From Woodblocks to the Internet. Chinese Publishing and Print Culture in Transition, circa 1800 to 2008*. Leiden and Boston: Brill.

Bronk, Heike, Stefan Röhrs, Alexander Bjeoumikhov, Norbert Langhoff, J. Schmalz, Rainer Wedell, Hans-Eberhard Gorny, Axel Herold and Ulrich Waldschläger. 2001. "ArtTAX®: A New Mobile Spectrometer for Energy-Dispersive Micro X-Ray Fluorescence Spectrometry on Art and Archaeological Objects." *Fresenius' Journal of Analytical Chemistry* 371 (3): 307–16.

Cams, Mario. 2017. *Companions in Geography. East-West Collaboration in the Mapping of Qing China (c.1685–1735)*. Leiden: Brill.

Cams, Mario, Leon Rodenburg and Fresco Sam-Sin. *QingMaps.org*. Digitally reassembled from Wang Qianjin 汪前进 and Liu Ruofang 刘若芳. 2007. *Qingting san da shice quantuji* 清廷三大實測全圖集, 3 Vols., Beijing: Waiwen chubanshe.

Cao, Wanru, Zheng Xihuang, Huang Shengzhang, Niu Zhongxun, Ren Jincheng and Ju Deyuan. 1990. *Zhong guo gu dai di tu ji: Zhan guo—Yuan* 中国古代地图集: 战国–元 (*An Atlas of Ancient Maps in China From the Warring States Period to the Yuan Dynasty, 476 B.C.–A.D. 1368*). Beijing: Wenwu chubanshe.

Cao, Wanru, Zheng Xihuang, Huang Shengzhang, Niu Zhongxun, Ren Jincheng, Qin Guojing and Hu Bangbo. 1994. *Zhong guo gu dai di tu ji: Ming dai* 中国古代地图集: 明代 (*An Atlas of Ancient Maps in China: The Ming dynasty, 1368–1644*). Beijing: Wenwu chubanshe.

Cao, Wanru, Zheng Xihuang, Huang Shengzhang, Niu Zhongxun, Ren Jincheng, Qin Guojing and Wang Qianjin. 1997. *Zhong guo gu dai di tu ji Qing dai* 中国古代地图集: 清代 (*An Atlas of Ancient Maps in China—The Qing dynasty, 1644–1911*). Beijing: Wenwu chubanshe.

Castro, Kepa, et al. 2008a. "Noninvasive and Nondestructive NMR, Raman and XRF Analysis of a Blaeu Coloured Map from the Seventeenth Century." *Anal Bioanal Chem* 391: 433–41.

Castro, Kepa, et al. 2008b. "Analysis of a Coloured Dutch Map from the Eighteenth Century: The Need for a Multi-analytical Spectroscopic Approach Using Portable Instrumentation." *Anal Chim Acta* 623 (2): 187–94.

Centeno, Silvia A. 2016. "Identification of artistic materials in paintings and drawings by Raman spectroscopy: Some challenges and future outlook." *Journal of Raman Spectroscopy* 47: 9–15.

Chang, Kuei-Sheng. 1979. "New Light on Cartography in Classical China." *Imago Mundi*, vol. 31: 10–17.

Chao, Xun 巢勛. 1979. *Jie zi yuan hua xiang* 芥子園畫像 [Manual of the Mustard Seed Garden]. Beijing: Renmin meishu chubanshe.

Chibbet, David. 1977. *The History of Japanese Printing and Book Illustration*. Tokyo, New York and San Francisco: Kodansha International Ltd.

Chou, Wen-shing. 2011. "Maps of Wutai Shan: Individuating the Sacred Landscape through Color", *Journal of the International Association of Tibetan Studies* 6 (December): 272–388.

Dennis, Joseph. 2015. *Writing, Publishing, and Reading Local Gazetteers in Imperial China, 1100–1700*. Cambridge: Harvard University Press.

Dorofeeva-Lichtmann, Vera. 2019. "'Inversed Cosmographs' in Late East Asian Cartography and the Atlas Production Trend." In *East-West Encounter in the Science of Heaven and Earth*, edited by Tokimasa Takeda and Bill M. Mak, 144–74. Kyoto: Institute for Research in Humanities.

Edgren, James Sören. 2011. "Late-Ming Erotic Book Illustrations and the Origins of Ukiyo-e Prints." *Arts Asiatiques* 66 (1): 117–34.

Ehrensvärd, Ulla. 1987. "Color in Cartography." In *Art and Cartography. Six Historical Essays*, edited by David Woodward, 123–46. Chicago: The University of Chicago Press.

Enzel, Kathrin, Oliver Hahn, Susanne Knödel and Jochen Schlüter. 2021. *Ausstellungskatalog Farbe trifft Landkarte/Exhibition Catalogue Colour Meets Map*. *Manuscript Cultures*, No. 16.

Fitzhugh, Elizabeth West, Marco Leona and John Winter. 2003. *Pigments in Later Japanese Paintings*. Washington, D.C.: Freer Gallery of Art, Smithsonian Institution Collection.

Forbes, Edward W. 1932. "Materials Used in Japanese Painting." *Bulletin of the Fogg Art Museum* 1, no. 3: 48–52.

Fuchs, Walter. 1943. *Der Jesuiten-Atlas der Kanghsi-Zeit: Seine Entstehungsgeschichte nebst Namensindices für die Karten der Mandjurei, Mongolei, Ostturkestan und Tibet mit Wiedergabe der Karten in Originalgröße*. Beijing: Catholic University Press.

Golas, Peter J. 1999. *Science and Civilisation in China, vol. 5: Chemistry and chemical technology, Part 13: Mining*. Cambridge: Cambridge University Press.

Goree, Robert. 2020. *Printing Landmarks. Popular Geography and Meisho Zue in Late Tokugawa Japan*. Cambridge and London: Harvard University Asia Center.

Hagen, Karl. 1928. "Eine Japanische Erdkarte mit Völkertypen aus der ersten Hälfte des 17. Jahrhunderts". *Mitteilungen aus dem Museum für Völkerkunde Hamburg, XIII, Festschrift zum fünfzigjährigen Bestehen des Hamburgischen Museums für Völkerkunde*, 143–56. Hamburg: Selbstverlag.

Hahn, Oliver, Doris Oltrogge and Holm Bevers. 2004. "Coloured prints of the 16th century—nondestructive analyses on coloured engravings from Albrecht Dürer and contemporary artists." *Archaeometry* 46 (1): 273–82.

Hahn, Oliver, Ina Reiche and Heike Stege. 2006. "Archaeology and Arts." In *Handbook of Practical X-Ray Fluorescence Analysis*, edited by. N. Langhoff, R. Wedell, B. Beckhoff, and B. Kanngießer. Heidelberg: Springer.

Han'guk Kojidojip P'yŏnch'an Wiwŏnhoe. 2012. *Kukt'o ŭi p'yosang/ Han'guk Kojidojip P'yŏnch'an Wiwŏnhoe* (*Land in Old Maps*). Seoul: Tongbuga Yŏksa Chaedan.

Hu, Philip K. (ed.). 2000. *Visible Traces. Rare Books and Special Collections From the National Library of China/ Zhongguo Guojia Tushuguan Shanben tezang jingpin xuanlu* 中國國家圖書館善本特藏珍品涖美展覽圖錄. New York [et al.]: Queens Borough Public Library [et al.].

Huang, Shijian. 2013. "The Exploration of Matteo Ricci's World Map." In *New Perspectives on the Research of Chinese Culture*, edited by Pei-kai Cheng and Ka Wai Fan, 119–36. Singapur: Springer Science+Business Media.

Hummel, Arthur William. 1938. "Chinese, Japanese and Other East Asiatic Books Added to the Library of Congress, 1937–38." *Report of the Librarian of Congress, 1938/ Division of Orientalia*, 210–37. https://lccn.loc.gov/2002530058.

Jang, Sang-hoon. 2006. "Detail Map of Korea: A great legacy lifetime devoted to compiling geography of the nation." *National Museum of Korea: Quarterly Magazine* 6: 8–11.

Jang, Sang-hoon. 2017. "Koreanische Kartografie und die Sammlung koreanischer Karten im Museum für Völkerkunde Hamburg. " In *Uri Korea. Kunsthistorische und ethnografische Beiträge zur Ausstellung*, edited by Susanne Knödel et al., 370–87. Hamburg: Museum für Völkerkunde Hamburg.

Jang, Sang-hoon et al. 2018. *500 Years of the Joseon Dynasty Maps*. Seoul: National Museum of Korea.

Janku, Andrea. 2010. "The Uses of Genres in the Chinese Press from the Late Qing to the Early Republican Period." In *From Woodblocks to the Internet. Chinese Publishing and Print Culture in Transition, circa 1800 to 2008*, edited by Cynthia Brokaw and Christopher A. Reed, 111–57. Leiden and Boston: Brill.

Kerlen, H. 1996. *Catalogue of Pre-Meiji Japanese Books and Maps in Public Collections in the Netherlands*. Amsterdam: J.C. Gieben.

Kogou, S., S. Neate, C. Conveney et al. 2016. "The Origins of the Selden Map of China: Scientific Analysis of the Painting Materials and Techniques Using a Holistic Approach." *Heritage Science*, 4.28. https://doi.org/10.1186/s40494-016-0098-x.

Komeie, Taisaku. 2016. "Self-Portrait of a Village." In *Cartographic Japan. A History in Maps*, edited by Kären Wigen, Sugimoto Fumiko, and Cary Karacas, 56–58. Chicago and London: The University of Chicago Press.

Kurtz, Joachim. 2010. "Messenger of the Sacred Heart: Li Wenyu (1840–1911), and the Jesuit Periodical Press in Late Qing Shanghai." In *From Woodblocks to the Internet. Chinese Publishing and Print Culture in Transition, circa 1800 to 2008*, edited by Cynthia Brokaw and Christopher A. Reed, 79–109. Leiden and Boston: Brill.

Lange, Diana. 2021. "Ostasiatische Karten/ East Asian Maps." In *Ausstellungskatalog Farbe trifft Landkarte/Exhibition Catalogue Colour Meets Map*, edited by Kathrin Enzel, Oliver Hahn, Susanne Knödel and Jochen Schlüter. *Manuscript Cultures*, No. 16, 289–368.

Lange, Diana. 2022. “Colour on Maps: Systems, Schemes, Codes.” *Imago Mundi*, vol. 74 (1): 117–24.

Lange, Diana. Forthcoming. “Mapping Qing Empire in 18th Century: Hand-drawn Maps from the ‘Qing Atlas Tradition’ at the Museum am Rothenbaum in Hamburg.” *Manuscript Cultures*.

Lange, Diana and Benjamin van der Linde. 2021. Einführung—Farbe trifft Landkarte/Introduction—Colour meets map. In *Ausstellungskatalog Farbe trifft Landkarte/Exhibition Catalogue Colour Meets Map*, edited by Kathrin Enzel, Oliver Hahn, Susanne Knödel and Jochen Schlüter. *Manuscript Cultures*, No. 16, 23–48.

Ledyard, Gari. 1994. “Cartography in Korea.” In *The History of Cartography. Cartography in the Traditional East and Southeast Asian Societies*, edited by J.B. Harley and David Woodward, vol. 2, bk. 2, 235–345. Chicago: University of Chicago Press.

Ledyard, Gari. 2008. “Maps and Mapmaking in Korea.” In *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, edited by H. Selin, 1310–17. Dordrecht: Springer.

Lin, Tianren 林天人 and Min Zhang 張敏 (eds.). 2013. *Huang yu sou lan: Mei guo guo hui tu shu guan suo cang ming qing yu tu* 皇輿搜覽—美國國會圖書館所藏明清輿圖: *Reading Imperial Cartography: Ming-Qing Historical Maps in the Library of Congress*. Washington D.C.: Library of Congress.

Mendes, Nuno et al. 2008. “Micro-Raman and Particle-induced X-ray Emission Spectroscopy for the Study of Pigments and Degradation Products Present in 17th Century Coloured Maps.” *Journal of Raman Spectroscopy* 39, 289–94.

Nam, Ji-Yeon, Kiok Han, Jeong-Eun Ji, Seung Kim, Hanhyoung Lee, Daiill Kang, Minsu Han, In-Sang Yang. 2016. “Raman spectroscopy of the pigments on Korean traditional paintings.” *Vibrational Spectroscopy*, vol. 85, July 2016, 181–84. https://doi.org/10.1016/j.vibspec.2016.04.011.

National Museum of Korea (ed.). 2007. *Kim Jeong-ho and his Daedongnyeojido, Territorial Map of the Great East*. Seoul: Yŏllin Pangmulgwan.

Needham, Joseph. 1976. *Science and civilisation in China*. Vol. 5, *Chemistry and chemical technology*. *Pt. 3. Spagyrical discovery and invention: Historical survey from cinnabar elixirs to synthetic insulin.* With the collaboration of Ho Ping-yii and Lu Gwei-djen. Cambridge: Cambridge University Press.

Ok, Young Jung. 2013. *Early Printings in Korea*. Seongnam: The Academy of Korean Studies Press.

Onodera, Atsushi and Shogo Hirai. 2021. 国絵図読解事典: *Encyclopedia of Kuni-ezu* (*Provincial Maps*) *of Japan in the Tokugawa Shogunate*. Tokyo: Sogensha.

Papelitzky, Elke. 2014. “A Description and Analysis of the Japanese World Map Bankoku sōzu in Its Version of 1671 and Some Thoughts on the Sources of the Original Bankoku sōzu.” *Journal of Asian History* 48 (1): 15–99.

Park, Hyunhee 朴賢熙. 2015. "Information Synthesis and Space Creation: The Earliest Chinese Maps of Central Asia and the Silk Road, 1265–1270". *Journal of Asian History*, vol. 49, No. 1–2, *Chinese and Asian Geographical and Cartographical Views on Central Asia and Its Adjacent Regions*, 119–40. Wiesbaden: Harrassowitz.

Pegg, Richard A. 2014. *Cartographic Traditions in East Asian Maps*. Honolulu: MacLean Collection, University of Hawai'i Press.

Pflug, Laura. 2019. "From 'All Under Heaven' to 'China in the World': Chinese Visual Imaginations from the Nineteenth and Early Twentieth Centuries." In *Mapping Asia: Cartographic Encounters Between East and West*, edited by Martijn Storms, Mario Cams, Imre Josef Demhardt and Ferjan Ormeling, 247–63. Cham: Springer.

Saburo Noma. 1974. "Earthquake Map of Japan, 1624." *Geographical Reports of Tokyo Metropolitan University* (9): 97–106.

Salter, Rebecca. 2013. *Japanese Woodblock Printing*. Honolulu: University of Hawai'i Press.

Simonova-Gudzenko, Ekaterina. 2019. "Gyōki-Type Shape: Representation of the Japanese Archipelago in East-Asian and Western Maps." In *Mapping Asia: Cartographic Encounters Between East and West*, edited by Martijn Storms, Mario Cams, Imre Josef Demhardt and Ferjan Ormeling, 125–45. Cham: Springer.

Singaravélou, Pierre and Argounès, Fabrice. 2018. *Le Monde vu d'Asie. Une histoire cartographique*. Paris: MNAAG and Éditions du Seuil.

Sivin, Nathan and Gari Ledyard. 1994. "Introduction to East Asian Cartography." In *The History of Cartography. Cartography in the Traditional East and Southeast Asian Societies*, edited by J.B. Harley and David Woodward, vol. 2, bk. 2, 23–31. Chicago: University of Chicago Press.

Stephenson, F. Richard. 1994. "Chinese and Korean Star Maps and Catalogs." In *The History of Cartography. Cartography in the Traditional East and Southeast Asian Societies*, edited by J.B. Harley and David Woodward, vol. 2, bk. 2, 511–78. Chicago: University of Chicago Press.

Stillo, Stephanie Elizabeth. 2016. "Putting the World in Its 'Proper Colour': Exploring Hand-Coloring in Early Modern Maps." *Journal of Map & Geography Libraries* (12): 158–86.

Sugimoto, Fumiko. 2016. "Introduction to Part I." In *Cartographic Japan. A History in Maps,* edited by Kären Wigen, Sugimoto Fumiko and Cary Karacas, 6–11. Chicago and London: University of Chicago Press.

Ting, Joseph S.P. (ed.). 1997. *History Through Maps: An Exhibition of Old Maps of China. Heyue cangzhen*: *Zhongguo gu ditu zhan* 河嶽藏珍: 中國古地圖展. Hongkong: Provisional Urban Council.

Toby, Ronald P. 2016a. "Mapping the Margin of Japan". In *Cartographic Japan. A History in Maps*, edited by Kären Wigen, Sugimoto Fumiko, and Cary Karacas, 24–27. Chicago and London: University of Chicago Press.

Toby, Ronald P. 2016b. "Spatial Visions of Status". In *Cartographic Japan. A History in Maps*, edited by Kären Wigen, Sugimoto Fumiko, and Cary Karacas, 78–80. Chicago and London: University of Chicago Press.

Tsien, Tsuen-Hsuin. 1984. "Technical Aspects of Chinese Printing." In *Chinese Rare Books in American Collections*, edited by Sören Edgren, 16–30. New York: China House Gallery, China Institute in America.

Tsien, Tsuen-Hsuin. 1985. *Science and Civilisation in China, Vol 5. Chemistry and Chemical Technology. Part 1: Paper and Printing*, edited by Joseph Needham. Cambridge: Cambridge University Press.

Tsien, Tsuen-Hsuin. 2004 [1962]. *Written on Bamboo and Silk—The Beginnings of Chinese Books and Inscriptions*. Chicago and London: University of Chicago Press.

Uesugi, Kazuhiro. 2016a. "Evolving Cartography of an Ancient Capital." In *Cartographic Japan. A History in Maps*, edited by Kären Wigen, Sugimoto Fumiko, and Cary Karacas, 66–70. Chicago and London: University of Chicago Press.

Uesugi, Kazuhiro. 2016b. "Historical Landscapes of Osaka." In *Cartographic Japan. A History in Maps*, edited by Kären Wigen, Sugimoto Fumiko and Cary Karacas, 71–74. Chicago and London: University of Chicago Press.

Unno, Kazutaka. 1994a. "Cartography in Japan." In *The History of Cartography. Cartography in the Traditional East and Southeast Asian Societies*, edited by J.B. Harley and David Woodward, vol. 2, bk. 2, 346–477. Chicago: University of Chicago Press.

Unno, Kazutaka. 1994b. "Maps of Japan Used in Prayer Rites or as Charms." *Imago Mundi*, vol. 46: 65–83.

Uyemura, Rokuro. 1931. "Studies on the Ancient Pigments in Japan." *Eastern Art. An Annual Published for the College Art Association*, vol. 3: 47–60.

Van der Linde, Benjamin. 2020. "Von den angewandten Farben zur funktionalen Kolorierungsmethode. Zur Entwicklung der Kolorierungsformen von Verlagslandkarten in der Zeit des späten 16. bis frühen 19. Jahrhunderts." *MEMO*_quer 1. Pdf-Format, doi: 10.25536/2020q001.

Van der Linde, Benjamin. 2021. "Karten für Kaufleute. See- und Elbkartenproduktion der Hamburger Commerzdeputation im ausgehenden 18. und beginnenden 19. Jahrhundert". *Zeitschrift des Vereins für Hamburgische Geschichte* 107: 21–60.

Verdier, Nicolas and Jean-Marc Besse. 2019. "Color and Cartography." In *Cartography in the European Enlightenment*, edited by Matthew Edney and Mary Pedley, 294–301. Chicago: University of Chicago Press.

Wigen, Kären, Fumiko Sugimoto and Cary Karacas (eds.). 2016. *Cartographic Japan. A History in Maps.* Chicago and London: University of Chicago Press.

Wigen, Kären. 2016. "Introduction." In: *Cartographic Japan. A History in Maps,* edited by Kären Wigen, Sugimoto Fumiko and Cary Karacas, 1–3. Chicago and London: University of Chicago Press.

Woodward, David. 2007. "Techniques of Map Engraving, Printing, and Coloring in the European Renaissance." In *History of Cartography*, edited by David Woodward, vol. 3, bk. 1, 591–610. Chicago: University of Chicago Press.

Wright, Suzanne E. 2008. "Hu Zhengyan: Fashioning Biography." *Ars Orientalis* 35: 129–54.

Wu, K.T. [Wu Guangqing 吳光清]. 1936. "The Development of Printing in China." *T'ien Hsia Monthly* 3: 137–60.

Wu, K.T. 1940. "Color printing in the Ming dynasty." *T'ien Hsia Monthly* 11: 30–44.

Wu, K.T. and Wu Kuang-Ch'ing. 1943. "Ming Printing and Printers". *Harvard Journal of Asiatic Studies*, 7.3 (Feb.): 203–60.

Xiao, Dongfa. 2010. "Categories, Features and Social Backgrounds of the Existing Wood Blocks for Printing in China." In *The History and Cultural Heritage of Chinese Calligraphy, Printing and Library Work*, edited by Susan M. Allen, Lin Zuzao, Cheng Xiaolan and Jan Bos, 71–86. Berlin [et al.]: de Gruyter Saur.

Xie, Guoxing 謝國興 and Tianren Lin 林天人 (eds.). 2015. *Fang yu sou la. Da Ying tu shu guan suo cang zhong wen li shi di tu* 方輿搜覽: 大英圖書館所藏中文歷史地 *Reading Antique Cartography: Historical Chinese Maps in the British Library*. Taipei: Institute of Taiwan History/Academia Sinica.

Xie, Guoxing 謝國興 and Zongren Chen 陳宗仁 (eds.). 2018. *Di yu zong lan: Fa guo guo jia tu shu guan suo cang Zhong wen gu di tu* 地輿縱覽: 法國國家圖書館所藏中文古地圖 *Reading Chinese Cartography: Historic Chinese-style Maps in the Bibliothèque Nationale de France*. Taipei: Institute of Taiwan History/Academia Sinica.

Yamasaki, Kazuo and Yoshimichi Emoto. 1979. "Pigments Used on Japanese Paintings from the Protohistoric Period through the 17th Century." *Ars Orientalis* 11: 1–14.

Yan, Ping et al. 1998. *China in Ancient and Modern Maps*. London: Philip Wilson for Sotheby's Publications.

Yang, Bo-gyeong, I Hyeon gun and Mun Sang-myeong. 2016. *Baeg du san go ji do jib: han gug go ji do sog ui baeg du san* (*Window to Mount Baekdu: Mount Baekdu in the old maps of Korea*). Seoul: Dong bug a yeog sa jae dan.

Yang, H.R., Lee, C.H. and Yi, J. 2021. "Analysis of pigments and damages for the 19th century White-robed Water-moon Avalokitesvara Painting in Gongju Magoksa Temple, Republic of Korea." *Heritage Science* 9: 139. https://doi.org/10.1186/s40494-021-00600-6.

Yee, Cordell. 1994a. "Concluding Remarks: Foundation for a Future History of Chinese Mapping." In *The History of Cartography. Cartography in the Traditional East and Southeast Asian Societies*, edited by J.B. Harley and David Woodward, vol. 2, bk. 2, 228–31. Chicago: University of Chicago Press.

Yee, Cordell. 1994b. "Reinterpreting Traditional Chinese Geographical Maps." In *The History of Cartography. Cartography in the Traditional East and Southeast Asian*

Societies, edited by J.B. Harley and David Woodward, vol. 2, bk. 2, 35–70. Chicago: University of Chicago Press.

Yee, Cordell. 1994c. "Taking the World's Measure: Chinese Maps between Observation and Text." In *The History of Cartography. Cartography in the Traditional East and Southeast Asian Societies*, edited by J.B. Harley and David Woodward, vol. 2, bk. 2, 96–127. Chicago: University of Chicago Press.

Yee, Cordell D.K. 2008. "Maps and Map Making in China." In *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, edited by H. Selin, 1284–91. Dordrecht: Springer.

Yonemoto, Marcia. 2013. *Mapping Early Modern Japan: Space, Place, and Culture in the Tokugawa Period, 1603–1868*. Berkeley and Los Angeles: University of California Press.

Yonemoto, Marcia. 2016. "The European Career of Ishikawa Ryūsen's Map of Japan." In *Cartographic Japan. A History in Maps*, edited by Kären Wigen, Sugimoto Fumiko, and Cary Karacas, 37–40. Chicago and London: The University of Chicago Press.

Yu, Feian. 1988. *Chinese Painting Colors. Studies of Their Preparation and Application in Traditional and Modern Times*. Hong Kong: University of Washington Press.