7 Materials and materiality as keys to understanding a map of Mount Kailash

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Abstract How does materiality matter when understanding Tibetan maps? While graphic and linguistic content is central to the identification of maps and can provide insights into the concepts and systems of rules, ideas and beliefs that led to their production, the materials that constitute maps may speak about manufacturing processes, the provenance of raw materials, the practical and technical knowledge of the mapmakers, and the use of the maps. This chapter underscores how the materials employed in Tibetan maps reveal aspects of their context and trajectory. Furthermore, materiality, conceptualized as a convergence of matter and imagination (Rosler et al. 2013: 15), can yield even more profound insights into artefacts like maps. Through a detailed case study of a map of Mount Kailash in the tangkha format and a specialized material-scientific analysis of the colourants employed in its creation, this chapter explores how a map can 'talk' (Daston 2008) through its materiality. With this case study it will show how Tibetan Studies can benefit from interdisciplinary collaboration. Crossing the field's traditional boundaries and working with other disciplines, we argue, is absolutely essential for serious research.

Keywords materiality, material culture, materials, map, tangkha painting, Mount Kailash, colourants, pigments, non-invasive analysis, scientific analysis

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Introduction: Spatial works and materiality

When I (Lange) entered the world of Tibetan maps around fifteen years ago, I started working on the materials in the British Library's Wise Collection (Lange 2020). These maps were first introduced to me when Toni Huber displayed a selection on a large computer screen in his office at the Humboldt-Universität zu Berlin. The digital format enabled the display of their seemingly infinite, minute details, which deeply impressed me. Only later did I have the opportunity to experience the originals in a British Library reading room. That was when I realized what a difference it makes to sensorially experience a map in physical form. Since then, I have seen many Tibetan maps in various places and at different institutions. I have worked with digitized versions, but having a map on a computer screen does not give you a sense of its original size or the materials of which it was made. You miss the true colour intensity, traces of use and the nature of the paper or canvas. Usually, you cannot see the back (where you can make exciting discoveries!) and sometimes you cannot read faint pencil notes and drawing lines. Moreover, having the original in front of your eyes brings you very close to the map maker's spatial world. You can smell the map, discover traces left on it by previous users and start travelling mentally through the landscapes it shows, some of which may be familiar. Touching a map with your fingers and feeling its soft or rough surfaces makes you think about the map maker who touched it before, how it must have felt to write or draw on that material, and what drawing and writing instruments they chose. If a map smells dusty and old, you think about where it was stored. Being so close to the drawing lines, to the different types of paper, to the colours and their shades, and to text written in ink many years ago produces a feeling of intimacy with both the materiality of the map and its maker. From time to time, you find blots, corrections and even fingerprints. Sometimes you hardly dare to unfold or turn a map because it seems so fragile. You start thinking about who made it, where, when, how and why, pondering the map's biography and how it ended up here, and wishing it could 'talk' to you. But how can we understand a map's messages?

As historian of science Lorraine Daston explains, things might not literally whisper or shout, but they do 'press their messages on attentive auditors, many messages, delicately adjusted to context, revelatory, and right to the target' (2008: 12). Such messages can be found in the materials of which objects are made. Sometimes they are easy to 'read';

sometimes they are hidden and need to be searched for. As this chapter will show, one of the best ways to learn, use and develop methods to understand these messages is through interdisciplinary collaboration. Taking the case of a Tibetan map of Mount Kailash, a sacred mountain in Western Tibet known in Tibetan as Gang Tisé (gangs ti se) or Gang Rinpoché (gangs rin po che),[1] it examines the possibilities that material scientific analysis can offer to the study of Tibetan maps and map-making processes more generally. As the main author who provides the knowledge and analysis of Tibetan maps, the chapter is written in my voice. But it is based on a collaboration with the second author, Oliver Hahn, a scholar from the natural sciences. We came together to explore the messages that maps communicate through materials and materiality, combining our respective expertise in Tibetan cartography and material culture studies (Lange) and in the non-destructive material analysis of colourants and writing and drawing materials (Hahn).

For a long period, the material nature of maps was taken for granted by many researchers even though, in many European languages, the terms for cartographic images derive from the materials on which they were drawn. The English word map, for example, derives from the medieval Latin *mappa* (large cloth). The Latin *carta* or *charta* (borrowed from the Late Greek *chartes*) originally meant a sheet of paper or parchment (Edney 2019: 74). Until relatively recently, geographers

1 This map is being studied as part of the research project 'Maps as Knowledge Resources and Mapmaking as Process: The Case of the Mapping of Tibet' (2021–2024), which is affiliated with the Cluster of Excellence Understanding Written Artefacts (research field Formatting Multigraphic Artefacts) at the Centre for the Study of Manuscript Cultures (CSMC), Universität Hamburg and led by Diana Lange as Principal Investigator. The core of this research project is to gain a new and more precise understanding of the materiality of maps and the processes of mapmaking using the example of the mapping of Tibet. Applying methods from the material sciences and taking both art- and cultural-historical as well as cartographical approaches, the project aims to provide a comprehensive historical and analytical account of maps of Tibet, their production and their significance. Its main outcome will be a monograph entitled *Tibet in 108 Maps: A Journey through Different Mapping Practices* (Brill) showing how different cultural and material conventions have influenced the formatting of the contents and shape of maps of Tibet. For further information see: https://www.csmc.uni-hamburg.de/research/cluster-projects/field-i/rfi07.html (accessed 22 July 2025).

did not view maps as visual and material artefacts, but rather judged them by the reality they depict (Jacob 1996: 192). Over the past few decades, however, the study of maps and mapping has been developing into a multi-faceted research field, with the materiality of maps and its significance for understanding maps and map-making processes attracting growing interest (see, e.g., Edney 2018). Furthermore, the primacy of essentially Western ideas about the importance of scale and accuracy as the sole criteria for assessing the quality of maps has been questioned and non-European Indigenous mapping has widened understandings of the field.[2]

Although I very much welcome the growing importance placed on the contextual understanding of maps and their material nature, in this chapter I want to emphasize their materiality. Maps are artefacts; they exist in different sizes, have different material properties and are made of different materials. Their outer appearance can change over time as they are handled, consumed and decay. Maps are not lifeless things; they have life cycles and social lives (Brook 2013; Lange 2020). But what exactly is their *materiality*? Art historian Michael Ann Holly regards materiality as 'the meeting of matter and imagination, the place where opposites take refuge from their perpetual strife' (cited in Rosler et al. 2013: 15). This definition applies very well to maps since it links the mapping process with the material choices made for a map's production and its resulting properties and capacities, such as its functions as an instrument for teaching, memory or orientation. In this sense, through the materiality of maps, the relationships and meanings that arise between people, human imaginings, materials and the environment become visible and tangible.

Although they are usually analyzed separately across the divide of the natural sciences and humanities, I argue that it is insufficient to look at matter and imagination as two separate aspects. The study of maps needs more diverse perspectives, not only from different cultures and regions but also by collaborating across academic disciplines. Using the example of the Tibetan map of Mount Kailash, this chapter shows how taking an interdisciplinary approach is essential

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2 The British map historian and former Head of Map Collections at the British Library Peter Barber, for example, underlined the 'seismic transformation in the study of maps' in his keynote delivered in 2019 at the *International Conference on the History of Cartography*; see Barbar 2020 for the published version.

if one is to produce innovative research that is recognized beyond the Tibetan Studies field. Moreover, it demonstrates how use of advanced technologies can give us access to important information and enables us to read stories told by maps that are still widely overseen in Tibetan Studies. I did not know of the technical and practical possibilities of material analysis when, in 2018, I joined the three-year interdisciplinary research project 'Coloured Maps', involving the University of Hamburg, the Hanseatic Business Archive Foundation and the Museum am Rothenbaum (MARKK) in Hamburg.[3] That project examined maps of East Asian and European origin that had been coloured by hand between the fifteenth and twentieth centuries, with a particular focus on the colours and colourants used for their production. The project's multidisciplinary approach and my close collaboration with Oliver Hahn (see, e.g., Lange and Hahn 2023) made me aware of the immense importance of scientific material analysis for the study of artefacts and the strong need for collaborative research and cooperation between the humanities and natural sciences.

This chapter opens a new branch of study, as we know of no existing material analyses of Tibetan maps prior to our research. First, it provides a short overview of Tibetan mapping and Tibetan maps, the material choices made for their production and how they have been studied. It then introduces the Kailash map and demonstrates the productive potential of a material analysis of the colourants used for its creation for gaining a better understanding of this map in particular and for map-making processes in general. It also exemplifies how materials are transformed into materiality through the imaginations of map makers and users.

Tibetan mapping and Tibetan maps

Tibetan maps, and in particular the map of Mount Kailash that will be introduced in this chapter, are an excellent case through which to explore maps as human-made products of their particular cultural, social and historical milieux, rather than as pure containers of spatial information. It is clear from the study of historical examples of Tibetan maps that Tibet has a remarkably rich and varied cartographic

3 For further information on the project, see https://www.csmc.uni-hamburg.de/coloured-maps.html (accessed 22 July 2025).

tradition. Tibetan maps have evolved over many centuries and assume many forms. Geographer Joseph Schwartzberg (1994) distinguishes between cosmographic and geographic Tibetan maps. The former include mandalas, the *bhavacakra* or wheel of life, lineage fields, the Mount Meru world-system, depictions of portions of the Buddhist universe such as various heavens and hells, and astrological and geomantic charts. Such maps were made to support religious education and meditation, as adjuncts to illuminated religious texts or to glorify places of religious importance such as pilgrimage sites. The number of known geographic maps from Tibet appears small in comparison with the cosmographic materials (Schwartzberg 1994: 612, 638), but nevertheless encompasses various genres including world maps, regional maps, town maps, monastery maps, route maps and maps of pilgrimage sites. Although Schwartzberg makes a basic distinction between cosmographic and geographic mapping, he was aware that this distinction does not always make sense and that some maps cannot be assigned exclusively to either category. For example, maps of pilgrimage sites, such as those of the sacred region around Mount Kailash, include numerous mythological places.

Historically, the rules governing the composition of Tibetan maps appear to have been far from uniform. General principles as to the 'correct' orientation of maps did not exist and it was common for map makers to use varying scales for different map elements. Many Tibetan geographic maps depict towns, monasteries and other specific localities, namely Lhasa and important monastic sites in Central Tibet. Tibetan map makers often adopted an oblique perspective, as if from a perch in space. This practice was possibly influenced by the physical environment. Over most of Tibet, there exist high vantage points from which largely barren expanses of land stretch before the observer like living maps (Schwartzberg 1994: 671–73). The use of such an oblique perspective for the production of maps brings us to the Tibetan term for map, *satra*, which has two spellings: *sa khra* and *sa bkra*. The latter translates as 'earth-beautiful', 'illuminated' or 'variegated' and refers to the outer appearance of maps. However, the majority of Tibetan maps that have a title use the spelling *sa khra*, which translates as 'earth eagle' or a 'bird's (-eye view) of the earth', in clear reference to the map maker's spatial perception of the area represented on the map.

Tibetans produced maps in various physical formats, of various materials and using different techniques. The majority of the surviving and accessible historical maps were made on paper or on textiles (mainly canvas) as manuscript maps.[4] We should bear in mind that these materials are technological products, not raw materials (see also Rosler et al. 2013: 34). They thus include the technological and material knowledge of their producers. There also exist maps in the form of murals drawn on the walls of monasteries, such as depictions of monastery compounds like Tashilhunpo; in contrast to manuscript maps, these murals are not portable.[5] Both manuscript and mural maps were drawn with various inks and colours consisting of colourants made from different raw materials. All Tibetan maps produced before the twentieth century are unique. Although woodblock printing had been used to reproduce texts in Tibet for hundreds of years,[6] this technique was apparently not used for map-making until the twentieth century. It was only then that Tibetans started to use woodblock or copperplate printing to produce maps that were then hand-coloured or left uncoloured.[7]

For the majority of Tibetan maps, neither the exact date of production nor the name(s) of the map maker(s) are known. But the materials of a Tibetan map can provide hints about its date of production and its maker(s), as well as its purpose, circulation, handling and users. Before a map is produced, material choices have to be made by its maker(s). These choices depend on their material knowledge, the availability and costs of materials, the map's purpose, size and content and, not least, the map's intended user(s). The use of expensive materials, for example, indicates that the person who commissioned or was to use the map was wealthy. Using exclusive colourants such as gold for selected map elements might also indicate the special meaning of those elements.[8] The colourants that a painter might use for a large-scale mural of a

4 I follow the definition of a manuscript as 'an artefact planned and realized to provide surfaces on which visible signs are applied by hand; it is portable, self-contained, and unique' (Lorusso 2015: 1).

5 There exist several such murals in the Nubra Valley north of Leh in Ladakh. According to an elderly monk they may have served to commemorate the place and to share it with others who did not have the chance to visit it in person (Kozicz and Lange 2018: 10).

6 For a history of Tibetan woodblock printing, see Helman-Ważny 2014: chapt. 5.

7 The earliest Tibetan printed maps were published in the Tibetan-language newspaper *The Tibet Mirror* (*yul phyogs so so'i gsar 'gyur me long*) published between 1925 and 1963 (Sawerthal 2018).

8 For example, the Golden Gate of Jerusalem is often coloured in gold on maps.

monastic complex like Tashilhunpo,[9] might be different from those they would use for a small-scale *tangkha* (*thang ka*; scroll work) painting drawn on canvas. For a route map drawn on thin local paper made of plants, a map maker would choose other and fewer colourants than for a similar map drawn on textile;[10] they would probably also use different drawing and painting techniques. The storage of maps also influences the choice of materials. A map maker would not use the same material for a map made to be hung and displayed on a wall as they would for a map made to be stored rolled up. Physical traces of use and wear, from inscriptions to cracks, faded colours and water damage, can also provide information about a map's use(s) and user(s). In short, Tibetan maps can send messages through the materials of which they are made.

Maps in context: A Tibetan map of Mount Kailash

Following Schwartzberg's (1994) loose categorization of Tibetan maps, the map of Mount Kailash (Figure 7.1) belongs to the group of Tibetan geographic maps emphasizing sacred places. In the past, such maps were usually displayed in monasteries to provide their audience with a visual guide to the places to be visited. From an art historical perspective, the Kailash map would be categorized as a 'monument painting', a genre of traditional Tibetan art that depicts important sacred monuments and places of pilgrimage. However, in catalogues and publications, such monument paintings may be found under a variety of genres, such as maps, pure lands, pilgrimage depictions, architectural views and topographic views (Arthur 2015: 10). Let us start by describing the map.

The map carries no title nor any information about its maker or place and date of production. The prominent pilgrimage site Mount Kailash and its surroundings are shown in great detail, including the pilgrimage circumambulation path. According to the Tibetan Buddhist narrative, Kailash was established as a Buddhist mountain as the result of a contest between the magical powers of two renunciates of

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9 See, for example, the maps of Tashilhunpo in the Nubra Valley, Ladakh, discussed in Kozicz and Lange 2018.

10 See, for example, the route map of the Tsari valley in southeastern Tibet described and discussed in Huber 1992.

Figures 7.1 The tangkha’s front side, size of the painting 39 × 49 cm. Photograph by Diana Lange.

Figures 7.2 The tangkha's reverse side, size of the painting 39 × 49 cm. Photograph by Diana Lange.

differing traditions; one Buddhist and one Bön.[11] The Buddhist hero of this myth was Milarepa (1040–1123), who is recorded as visiting the place in 1093; his Bönpo counterpart was Naro Bönchung (eleventh century) (McKay 2015: 293f). The map provides a visual representation of this magical duel. Both competitors are shown in the upper part, Milarepa sitting on top of Mount Kailash and Naro Bönchung flying on his magic drum. The large blue lake in the map's lower part represents Lake Manasarovar (mtsho ma pham). It is surrounded by several monasteries, seven of which are named. These appear to correlate with seven of the eight monasteries associated with the lake mentioned in the late nineteenth-century Kailash pilgrimage guide written by the 34th Drigung Kagyü hierarch Könchok Tendzin Chökyi Lodrö Trinlé Namgyel (trans. Huber and Tsepak Rigzin 1995). The following are the names inscribed on the map (clockwise from the yellow building), together with the spellings from the pilgrimage guide and their translation by Huber and Tsepak Rigzin [in square brackets]:

(1) sergyi ja khyim (gser gyi ja khyim) [gad pa gser kyi bya skyib?; the bird shelter of golden bluff]
(2) gotsur ('go tshur) [mgo tshugs; the beginning]
(3) khangba (khang rba) [glang sna?; the elephant's trunk]
(4) nyengo (gnyen sgo) [mnyes mgo; the pleased head]
(5) trügo lho ('khrus sgo lho) [khrus sgo lho; southern bathing entrance]
(6) jiu gön (byi'u sgon) [byi'u dgon; small bird]
(7) sera lung (se ra rlung) [se ba lung; thorn bush valley].[12]

As shown in Figures 7.1 and 7.2, the map is made of different materials in the style of a traditional Tibetan tangkha painting or scroll work. It is drawn with ink and colourants on a canvas that is bordered with red and yellow silk, and sewn to a cloth frame made of light green silk on the front and light blue cotton on the back. The silk feels incredibly smooth and soft—completely different to the brocade fabric often used

11 The Bön tradition has its own narratives about Mount Kailash, a mountain that is also sacred for Hindus and Jains. See, e.g., Loseries-Leick 1998; McKay 2015.

12 For further details and descriptions of these monasteries see Huber and Tsepak Rigzin 1995: 37–9.

for tangkha production. The inner and outer seams on the front side of the frame are reinforced with cord. Cotton cords are also fixed at the upper part to hang the tangkha. The canvas is protected by a yellow-orange silk cover; this is lifted and held up by two violet silk ribbons to display the map. These ribbons are also used to tie the tangkha when it is rolled for storage or transport. On the tangkha's upper and lower parts, the typical wooden batons embedded in the textile act as weights that support the straight hanging of the tangkha and retention of its shape. The lower baton's ends are covered with metal finials.

I purchased the map from the German auction house Kiefer Buch- und Kunstauktionen in 2021.[13] Since I had not seen many maps of Mount Kailash I was primarily interested in its content. Like the maps from the Wise Collection, I first encountered the Kailash map in a digital format in the form of the photographs that the auction house shared with me. It was delivered in a cardboard tube and carefully swathed in plastic wrap. When I unpacked and unrolled it, I once again became aware of the great contrast between digital and physical forms. With the original map in front of my eyes, I could clearly see its age and many signs of use. The colours differed from those on the photographs. Similar to my first experience with the physical maps in the Wise collection, I was suddenly transported into the world of the mapmaker and asking the questions that arise every time I see a map for the first time: who made it, when, where, why and how? I had to help it talk.

I was able to discern some of the messages in the map's materials without using advanced technologies. For example, it was clear from its component parts that its production involved people from different handicraft trades, such as painters, tailors and metal workers, and had depended on their technological and material knowledge.[14] I was also

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13 The auction house is based in Pforzheim (see http://www.kiefer.de [accessed 22 July 2025]) and the auction number was 117-1845. I am aware of the ongoing debate on the role that academics might play in the trade of objects from the Himalayas (e.g., Smith and Thompson 2023). This was the first time I had purchased an object from an auction house. My initial motivation was to avoid this object ending up in a private collection and being lost for research. When I received the tangkha I was very irritated that the auction house provided no information about its provenance and did not respond to my inquiry about this. I had suddenly arrived in the reality of the market.

14 For further in-depth information on the production of Tibetan tangkha see Jackson and Jackson 1988.

able to surmise from the condition of the materials and their evident wear that the tangkha had been used extensively over a long period. On the upper part of its cover, there are traces of insect damage. The colour of light-green silk on the front side is faded. The map also shows signs of wear in places, as well as some water damage, cracks and fractures. This tangkha, like others, would have been designed to be portable, and would have been kept rolled up when being transported or when not being hung. Most tangkhas have been rolled up and down many times over the course of their life. This handling causes damage to the fabric, and it is not unusual to find horizontal and vertical breaks on the canvas—like those on the piece introduced here. Indeed, I would have preferred not to roll it up again to avoid further damage. While the tangkha does not show evidence of old repairs, the wear-related condition of its materials (faded silk, stains, cracks, fractures) tells us something about its life.

Other messages, however, were only revealed by combining my knowledge with that of Hahn in a historically and culturally contextualized material scientific analysis of the colourants used in the map's production. As the next section discusses, our cross-disciplinary collaborative analyses allowed the map to reveal certain clues about its age and place of origin.

Shedding scientific light on the Kailash map

The map was drawn using different colours, namely blue, green, red and yellow in different shades, as well as white and black. The painter used different colourants, most of which are opaque. Colourants can be divided into two subgroups, pigments and dyes, which are prepared in different ways. Pigments are not soluble in bonding agents and solvents, so they are visible as small particles when viewed through a microscope, whereas dyes dissolve and cannot be discerned as individual particles. This difference plays a role in the choice of a suitable method for material scientific analysis. As a general rule, pigments are inorganic compounds—metallic salts like oxides, carbonates or sulphides—which can easily be identified by the presence of so-called 'marker elements'. They might be natural pigments, obtained as minerals from corresponding deposits, or artificial pigments that have been produced. Natural dyes, in contrast, 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) have also been available since coal tar dye chemistry was developed in the middle of the nineteenth century. By identifying the colourants used to produce the Kailash map and situating their use in historical and cultural context, it was possible to reach some conclusions as to the provenance of some of the component raw materials and, perhaps more significantly, about when the (undated) map was made.

Methods of analysis

For most of our material scientific analyses of the map we applied 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 has to do with the kind of excited light used—visible light (VIS), ultraviolet light (UV), infrared light (IR) or X-rays—and the structure or composition of the material. After a brief disturbance, the material returns to its original basic state. This relaxation process leads to the release of characteristic radiation which, properly interpreted, provides indications of the composition of the investigated material.

Our investigation started with the use of a visible light microscope, which gave us information about the main characteristics of the map's material components, for example, differences between paper and textile, details of drawing and colouring technology, and damage or overpainting, as well as the use of soluble dyes and insoluble pigments in the map. We then carried out a two-wavelength reflectography using a handheld microscope equipped with UV and near-infrared (NIR) light. With UV or IR light, the absorption and reflection of the radiation provides initial knowledge about the map's material characteristics. For example, NIR light allows us to distinguish between different black writing and drawing materials such as carbon inks and iron gall inks, while UV light helps us to see where the painting has been restored or damaged (Figure 7.3).

The next step was to use X-ray fluorescence analysis (XRF) and visible (VIS) spectroscopy to identify the pigments that the map maker used for different colours. Like optical microscopy and wavelength reflectography, XRF and VIS spectroscopy are both non-destructive, non-invasive methods. XRF analysis is one of the classic methods for

Figure 7.3 Two-wavelength reflectography, carried out with a hand-held USB microscope equipped with in-built light sources at 365 nm (left column) and 940 nm (right column), and an external lamp in the visible range (middle column). While most colourants become transparent in the NIR (near-infrared), carbon ink absorbs significantly in this wavelength range and appears black. The UV image makes corrections—or in this case damage—more obvious.

investigating the elemental composition of inorganic-based pigments (Hahn, Reiche and Stege 2006: 687–700; Mantler and Schreiner 2000). It is an atomic process in which an atom of the material under investigation returns to its ground state after excitation by emitting specific radiation. At the beginning of the process, the incident beam interacts with the inner shell electrons of the atom and one of these electrons is removed. To restore the equilibrium of the atom an electron from an outer shell, which has a higher energy level, then takes the place of the knocked-out electron. The excess energy of the electron that has moved into the inner shell is emitted as X-ray radiation or 'fluoresence'. Since only very specific electron transitions are possible for specific elements, the excited element can be identified from the energy position of characteristic X-ray fluorescence peaks. The height of the peak corresponds to the amount of the element within the sample. As shown in Figure 7.4, the presence of particular elements, for example mercury or copper, provides an indication of the inorganic pigments that have been used for certain colours, for example, cinnabar (red) or malachite (green).

VIS spectroscopy is another technique that allows the identification of coloured materials (Fuchs and Oltrogge 1994: 133–171, 603). Strictly speaking, VIS spectroscopy can be only applied to coloured or chromatic substances. Achromatic colours (black, white, greys) cannot be

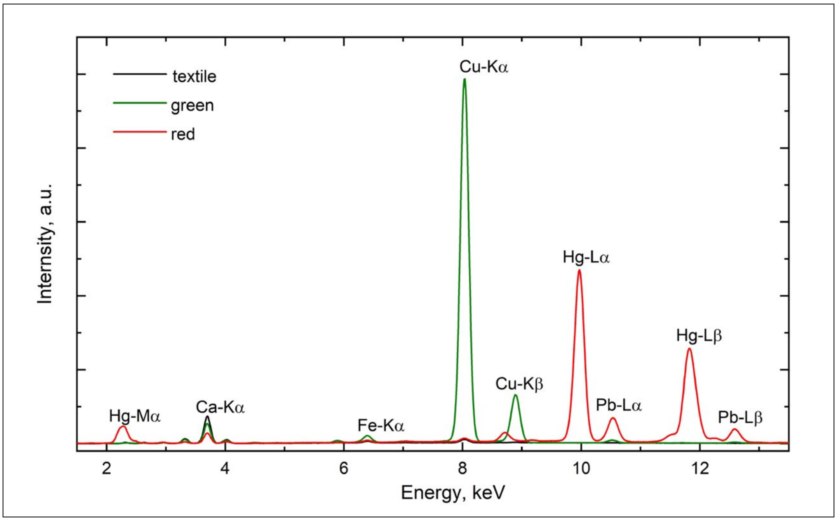

Figure 7.4 XRF spectra of the green and red colours on the map. The presence of mercury (Hg) indicates cinnabar (mercury sulphide), whereas the element copper (Cu) indicates a copper green pigment (probably malachite). The small amount of calcium (Ca) results from the supporting textile.

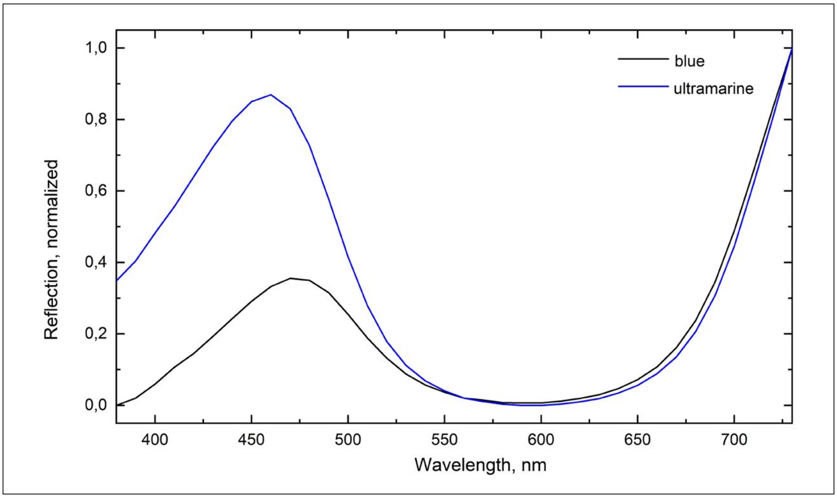

Figure 7.5 VIS spectra of a blue area with corresponding reference curve of ultramarine. The similarity of the course of both reflection curves is obvious.

analysed with this technique. When visible light interacts with coloured matter, the latter absorbs specific parts of the incident light and reflects other parts. The resulting reflection curve, which reveals the correlation of the reflected light as a function of the energy of the excitation radiation, is specific to each dye and can be used for the differentiation of, for example, red dyes such as brazilwood or cochineal or blue pigments such as indigo and ultramine (for a reflection curve of ultramarine, see Figure 7.5). In general, the method works quite well for determining the mineral pigments and organic dyes used until the end of the eighteenth century (Hahn, Oltrogge and Bevers 2004: 273–282). With the development of 'tar dyes' many artificial pigments and dyes were produced from the middle of the nineteenth century. Since their reflection curves are very similar, the extent to which we can distinguish these synthetic colourants is limited (see also Lange and Hahn 2023: 40–42).

Situating the results in historical and cultural context

Our material scientific analyses of the Kailash map show the different colourants used in its production. Cinnabar (*mtshal*) was used for the red elements (Figure 7.4), ultramarine for blue (Figure 7.5), chrome yellow for yellow and calcium white (*ka rag*) for white. The green parts were painted using a copper green pigment (Figure 7.4), probably malachite (*spang*). Mixing blue and yellow dyes and pigments to obtain green, although common in other parts of the world,[15] was not preferred by Tibetan artists (see also Ricciardi and Pallipurath 2016: 487). For black, the painter used carbon ink (Figure 7.3).

The choice of malachite, cinnabar and calcium white corresponds with the traditional mineral pigments (*rdo tshon* and *sa tshon*; stone colours and earth colours) that were used extensively for tangkha painting in Tibet (Elgar 2006: 102; Jackson and Jackson 1976). Many of them were mined locally. The main source of malachite was Nyemotang (snye mo thang) in Tsang.[16] Tibetan artists used both native

15 In East Asia, for example, a mixture of indigo and gamboge (or orpiment) and orpiment and Prussian blue was quite common. See also Lange and Hahn 2023: 54.

16 Because of its importance the Lhasa government strictly controlled the mining and distribution of malachite; artists usually obtained it directly or indirectly through a government office (Jackson and Jackson 1976: 274).

and synthetic mercury sulphide for their red. The native mineral *cog la* (or *mtshal rgod*; cinnabar) occurs naturally in some parts of south-eastern Tibet, while synthetic mercury sulphide vermillion (*mthsal* or *rgya mtshal*; Chinese vermillion) was imported to Tibet from India and China where it has been synthesized since ancient times (Jackson and Jackson 1976: 277). The white paints of Tibetan artists were all calcium minerals available throughout Tibet, the most well-known deposit being at Rinpung (rin spungs) in Tsang.[17]

While malachite, cinnabar and calcium white are traditional mineral pigments used for tangkha painting in Tibet, this is not true for the two pigments that were identified for the yellow and blue elements, namely chrome yellow and ultramarine blue. Traditionally, the mineral pigments azurite (*mthing*) and orpiment (*ba bla*) were used to tint blue and yellow areas on Tibetan tangkhas (Jackson and Jackson 1976: 277, 279). The main source for azurite in Tibet was also Nyemotang in Tsang and the most famous deposit of arsenic trisulphide orpiment was in Kham (East Tibet) near Chamdo (Jackson and Jackson 1976: 274, 278). So where did the map maker's chrome yellow and ultramarine come from?

In their analysis of fifteen pigment samples from wall paintings on the pilgrimage corridor at the Jokhang Temple in Lhasa, Li et al. (2014) found not only the traditional mineral pigments azurite, malachite, cinnabar and calcium white, but also many synthetic pigments including ultramarine blue and chrome yellow. They suggest that the wall paintings in the Jokhang Temple were executed after the 1850s, mostly around the 1900s (Li et al. 2014: 5). The synthetically produced pigment chrome yellow is created when a chromate solution is added to dissolved lead. Lead chromate was first synthesized by the French chemist Louis Nicolas Vauquelin in 1809. But it was only when major deposits of chromium were opened up for mining in France, Great Britain and the USA from about 1820 that chrome yellow was established as a colourant (Kühn and Curran 1986; Li et al. 2014: 5). It began to be widely used as a pigment in watercolours, coach paintings and oil paintings in the second quarter of the nineteenth century. Another French chemist discovered the process for synthesizing ultramarine in

17 Jackson and Jackson (1976: 280) state that according to Tibetan nomenclature there exist two varieties of this calcium white, which are designated masculine (*po*) and feminine (*mo*). The masculine type (*po rag* or *po dkar*) is harder and coarser, the feminine type (*mo rag* or *mo dkar*) is relatively soft and fine.

the late 1820s. By the 1830s, it was being produced in large quantities in Europe and soon became the most popular deep blue.

When and under what circumstances did synthetic pigments from Europe find their way to Tibet? Pigments and dyes had been common articles for trade for centuries all over the world. With the growth of European empires, new synthetic pigments from Europe were swiftly and thoroughly assimilated in Asia, especially from the nineteenth century onwards. For example, 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. From the eighteenth century onwards it quickly replaced the organic dye indigo for colouring rivers and bodies of water on East Asian maps (Lange and Hahn 2023: 62).

Historical records indicate that during the 1840s, the pigments imported into Nepal and then into Tibet by the British East India Company included vermilion, red and white lead, and indigo (Hodgson 1874: 101). The Chinese painter Yu Feian mentions in his work on Chinese painting colours that, after the Opium War in the mid-nineteenth century, foreign synthetic pigments were imported in increasingly large amounts. Some of them replaced traditional mineral pigments as they were inexpensive, gave good results and were convenient to use (Yu 1988: 30).[18] European synthetic paints may have been introduced into Tibet via India or China, and their availability and affordability probably increased in the early twentieth century. The synthetic pigments applied in the Jokhang wall paintings were most likely introduced into Tibet no earlier than the 1850s (Li et al. 2014: 5). Thus, it can be assumed that these pigments were also not used for tangkha painting before the mid-nineteenth century. In their analysis of six Tibetan tangkha paintings produced between the eighteenth and twentieth centuries, Mass et al. (2009) only identified the pigments ultramarine blue and chrome yellow on twentieth century tangkha paintings. They found it 'notable

18 Yu's (1988) manual is one of the richest sources on Chinese painting colours and their historical development. It was originally published in Chinese in Beijing in 1955 under the title *Zhongguohua yanse de yanjiu* (Research on Chinese Painting Colours). As well as sharing 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, and a detailed list and table of recipes for mixing colours (33–34, 68).

that pigments introduced in the early 19th century in the West do not show up in Himalayan tangkhas until the 20th century' (115).[19]

The fact that ultramarine and chrome yellow were found among the colourants used for painting the map of Mount Kailash suggests that it was not made before 1850 and probably in the late nineteenth or early twentieth century. But this still leaves us with an important question: Why did the painter choose these two artificial pigments? Their use of artificial ultramarine blue instead of the traditionally used azurite might have been partly a question of cost. According to Jackson and Jackson, azurite was not expensive, but because it was used in great quantities for areas like sky, and since it had to be applied fairly thickly to achieve the deeper colours, it used to account for a great portion of a painter's expenses (Jackson and Jackson 1976: 275–76). The preference for ultramarine over azurite, as well as for chrome yellow over orpiment, may also be due to the fact that these two artificially produced pigments are significantly more intense in colour. In high-altitude areas like the Tibetan plateau colours generally seem more intense to the human eye, in particular the blue sky or blue lakes. So it is not surprising that this intensity is reflected in the use of colours for paintings on monastery walls, for painting wooden elements in architecture and, of course, for the production of tangkhas. It is therefore possible that the tangkhas painter wanted to use the most intense pigments available to produce the map of Mount Kailash. Moreover, in addition to their colour-intensive character, both pigments age less. In the case of orpiment, the painter might also have had in mind the widely known toxicity of the substance.[20]

While the map's colourants hint at the provenance of its raw materials and *when* it was produced, we can only speculate about the place of its production. We cannot exclude the possibility that the map was made not in Tibet but in Nepal. It is probably linked to a very similar map located in Tragyam Monastery in Dolpo, north-western Nepal on the border with Tibet (Figure 7.6).[21] It would be highly interesting to

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19 Richard Ernst also analysed the pigments of several Tibetan tangkhas. He found chrome yellow on one and for this reason suggests that it dates to 'well in the 19th century' (Ernst 2014: 9).

20 Today we know that chrome yellow is also a toxic pigment.

21 A photograph of this map taken by Edward Worcester is reproduced as the frontispiece for the first issue of volume five of the *Kailash* journal (1977) and in Alex McKay's (2015) book on constructions of Kailash's sacred geography.

Figures 7.6 Map of Mount Kailash at Tragyam Monastery in Dolpo (photograph by Edward Worcester).

Figures 7.7 Map of Mount Kailash introduced in this chapter (photograph by Diana Lange).

conduct a material analysis of the colourants used for the production of that map to see if the same materials were used and if the provenance of both maps is linked.

Another similar map can be found in the Himalayan Art Resources Database, https://www.himalayanart.org/items/84054 (accessed 24 July 2025) Thomas Laird Collection (item 84054, from Tibet, date range 1800–1899).

Recovering damaged writing

In addition to the clues revealed by material scientific analysis of the map's colourants, imaging technology also allowed us to decipher a message that had been left on its reverse. During careful examination of the back of the Kailash map, traces of a pencil inscription were visible. This inscription could not be seen on the photographs provided by the auction house. Even once the original was in my hands, parts of the inscription were indiscernible to the naked eye (Figure 7.8), but we were able to decipher them with the help of infra-red photography (Figure 7.9).

Figure 7.8 Extract of the reverse side showing the pencil inscription. Image Capture by Gerald Schnittger and Annette Keller, PhaseOne. Image Processing by Ivan Shevchuk, CSMC, University of Hamburg.

Figure 7.9 Infrared photography of the inscription. Image Capture by Gerald Schnittger and Annette Keller, PhaseOne. Image Processing by Ivan Shevchuk, CSMC, University of Hamburg.

In the work of recovering damaged writing, imaging hardware plays a significant role. Multi-spectral imaging captures image data within specific wavelength ranges across a broad electromagnetic spectrum. The wavelengths can be separated by filters, generated by LEDs, or captured using camera systems sensitive to specific wavelengths, including light at frequencies outside the visible light range, such as infrared and ultraviolet. These procedures can allow the extraction of information that the human eye cannot capture with its visible red, green and blue receptors. Due to the material-dependent interplay between reflection, absorption and transmission, texts that have been lost due to aging, damage or reuse can be made visible again (Janke and McDonald 2014: 113–24). In the case of the Kailash map, the coating on the back had crumbled and fallen off in places, making parts of the inscription illegible. Scientific light allowed the Tibetan map to talk through materials that had (partly) faded away.

The inscription reads ‘Gang rinpoché lama künchok sumla chak tselo’ (I pay homage to the Precious Snow Mountain, the guru and the Three Jewels).[22] This is a prayer that was probably written by the owner of the tangkha. Inscriptions such as holy mantras and syllables on the reverse side of Tibetan tangkhas are relatively common. However, they are typically written by the artist monks with red or black ink in preparation for the consecration ceremony. Here, the pencil inscription is probably a physical trace left by the map user. Such inscriptions made by the user, and with a pencil, are rather unusual. It is possible that the tangkha was not used in a monastic context but was commissioned by a person who had perhaps completed the pilgrimage to Mount Kailash and wanted to have a visual and material reminder of this experience. Or perhaps they did not have the chance to visit in person but wanted to have a visual representation of Mount Kailash for meditation purposes. We do not know. We can only speculate about the purpose of the map.

Concluding remarks: The meeting of humanities and science

According to the traditional division of expertise within academia, philologists exclusively engage with textual aspects of sources while art historians and archaeologists address their visual or material components. These disciplinary boundaries limit our understanding of artefacts such as Tibetan maps, tending to obscure the shared materiality and regional provenance of the materials employed in their construction. Our analysis of the Kailash map shows the productive potential of a cross-discplinary approach. By combining our respective

22 The spelling used in the inscription is *gang ris rin ’po chen bla ma kun mchog sum la chags tshal lo*. The correct spelling of this prayer is *gangs rin po che bla ma dkon mchog gsum la phyag ’tshal lo*. I am very grateful to Huadan Zhaxi (Central Asian Seminar, Humboldt Universität zu Berlin) for discussing the spelling of this inscription with me.

expertise in Tibetan cartography and material culture studies, on the one hand, and in the non-destructive material analysis of colourants and writing and drawing materials, on the other hand, we have been able to uncover messages within the materials of which the map was made—messages that would otherwise have remain hidden. Humanistic and scientific collaboration has made it possible to both identify component materials through material scientific analyses *and* to place those materials in the historical and cultural context in which the map was made, drawing out its complexity as a social artefact. In short, we have been able to bring together the materials the map was made of (matter) with its cultural meaning (imagination).

This *meeting of matter and imagination* offers insights into who made the map, how, when and why. What we have here is a geographic map foregrounding a prominent pilgrimage site in Western Tibet. The mapmaker shared spatial ideas about this place, provided inscriptions for selected monasteries and offered a visual representation of a Buddhist narrative closely connected to Mount Kailash. The form and content of the map are clearly intertwined. The content suggests that the map was used in a religious context and explains its framing in the form of a tangkha, tangkha painting being a genre of Tibetan religious art. The map's style suggests a maker who was familiar with traditional Tibetan mapping practices. Numerous human imaginings of and knowledge about Kailash and its environs are materialized in and circulated through this map, which was both portable and displayable. But other places also come into play when we follow the materials that the map maker used. Scientific analysis of those materials informs us about both matter and global flows of materials and technologies. It tells us that in the making of the Kailash map, artificial pigments from intercontinental trade came together with materials predominantly obtained locally in Tibet. Multiple people in different roles contributed to the production of this map. It has been used and probably touched by many hands and seen by many eyes. Its producer will have had both the purpose of the map and its intended users clearly in mind when making their material choices. Although we could not witness the map's manufacturing process, scientific methods have made it possible to trace at least part of the story of its production and given us important clues as to when it was made, while signs of wear have also helped us to trace part of its use and history—up to its sale at an auction in Europe.

Despite our intensive collaboration on this case study, we feel that we have only scratched the surface of the benefits of interdisciplinary cooperation. The team could easily be expanded by scholars from other disciplines such as paper analysis, restoration, art history or textile studies. Nevertheless, we hope that our work stimulates further crossing of traditional boundaries in the field of Tibetan Studies, both as a way to help our sources talk and to make research in this field more visible to a broader audience.

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