

Agnieszka Helman-Ważny

Epilogue

In this epilogue, I would like to summarise our research flow over the recent years and conclude with a reflection on the cross-disciplinary methods that were developed and tested during our research, aiming at the material characterisation and provenancing of the set of sixty-five *tsakali* that are the subject of this volume.

The protocol of this study has been developed and constantly adjusted to adapt to the results obtained over the period of research. From basic information and assumptions, we moved to well-informed facts retrieved by historical, codicological and scientific analyses conducted by fourteen scholars from the fields of Tibetology, art history, paper history and science, archaeometry, computer-based sciences and hard sciences at the Centre for the Study of Manuscript Cultures at Universität Hamburg; the German Electron Synchrotron (DESY) in Hamburg; the École pratique des hautes études (EPHE) in Paris; and the School of Oriental and African Studies (SOAS) at the University of London. Though it was not possible to answer all the questions, the results of our independent analyses enabled a far better understanding of the complexities of both the object examined and various cross-disciplinary methodologies.

The research questions asked throughout this book can be divided into two groups, one related more directly to the object, and the second concerning the methodologies. Thus, we started with a set of questions such as: to which tradition does the *tsakali* set belong? Where and when was it produced? Were all the cards manufactured at the same time? What can they tell us about the ritual expert or spiritual teacher who owned them? Later on, as we studied the material further, we arrived at more questions, such as: what can we see in the data from different methods? Do these results support each other or not? How should we interpret the data? Which methods best complement each other?

The introductory remarks to this book explain the concept and framework of the case study. The ensuing chapters present the results obtained by each method separately, allowing for different perspectives driven by these different methodologies and the disciplines they belong to. It is necessary, however, to understand the challenges faced by such a cross-disciplinary study, and this epilogue offers an explanation and extended discussion of the results that were first assessed independently of the other perspectives, and then integrated and interpreted collec-

tively. In this way, the reader can learn how the selection of methods we applied justifies a holistic study of one object.

As explained in the introduction to this book, material analyses often require more time, or the use of a high-performance laboratory and equipment that entail high costs that have to be justified. This is why a selection of parts or features of the object to be studied, or measured, is an extremely important task to start with, because it is often impossible to analyse entire elements and components of an object. This also conditions the order of both the methods used and the parts of the object to be studied. A summary table of the analyses conducted for each *tsakali* concludes the introductory part.

For example, while the text of all sixty-five cards was translated, and all the cards photographed in different light and inspected for the technological features of their paper, it was impossible to perform fibre analyses, radiocarbon dating, X-ray, FTIR or Raman measurements for all cards. In the case of radiocarbon dating or fibre analysis, due to the destructive nature of these methods, the sampling had to be limited to a small, representative group of cards. Thus, in some cases, due to the incompatibility of different approaches, the amount of material examined was much smaller than in others. For example, the amount of data obtained at the nanoscale excluded the possibility of examining all the cards, due to the time and labour it would have taken to do so. This was relevant for the scaling of the object, depending on the scale at which the object was examined. The different methods that were applied at different scales are shown in Fig. 1.

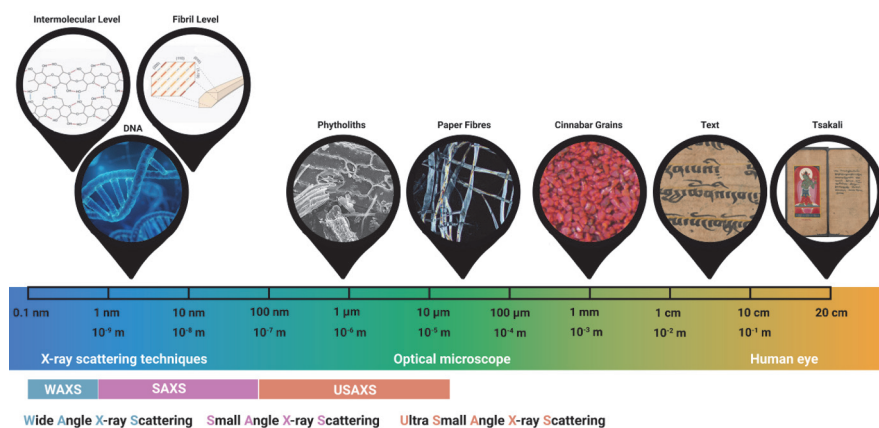


Fig. 1: The scales at which particular elements and materials of the object were examined.

The artefact (the set of *tsakali*) was composed of different elements made of a variety of materials through the application of specific techniques and technologies. Generally speaking, the cards are composed of (1) images on the recto sides of the cards, painted over the primer, executed first on a paper support; and (2) text written on the verso sides of the cards (Fig. 2). With respect to the material components, these include paper, ink, colourants and all the individual basic components of these materials, such as pigments, binding media, carbon black, fibres and sizing substances, among other things.



Fig. 2: Main elements of the *tsakali* submitted to material analysis.

The complexity of the object made it obvious that we needed different methods, and that there was no single one that would be able to answer all our research questions. The diagram below illustrates the outline of the cross-disciplinary analysis applied to the Zhangzhung Nyengyü *tsakali* collection (Fig. 3). To understand the complexity of this object, we needed to differentiate between its components – to separate its elements to see how they work and how they can be studied, first individually and then together as a single object.

The Zhangzhung Nyengyü Tsakalis: A Cross-Disciplinary Analysis

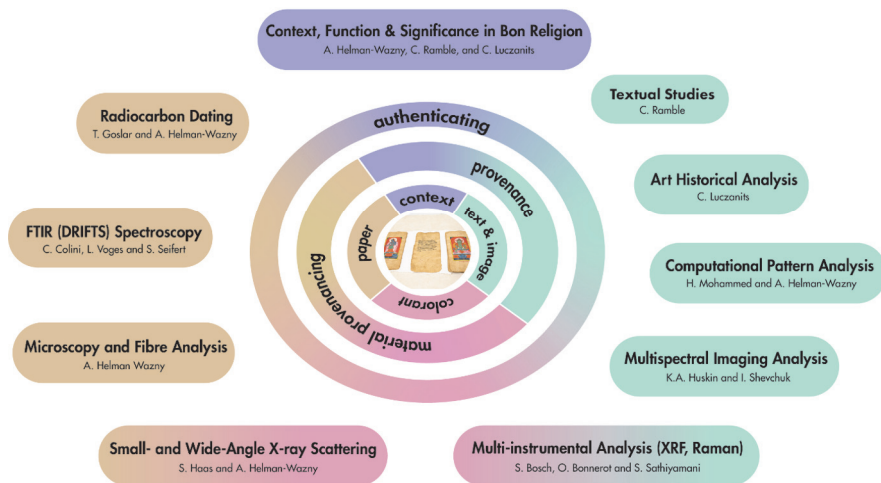


Fig. 3: Outline of the cross-disciplinary analysis of the Zhangzhung Nyengyü *tsakali* collection.

The material object cannot be fully understood without its social, artistic and cultural context. Due to the specific function of these ritual cards, it was especially important to understand this context. This is why Chapter 2 was absolutely necessary as a starting point for our investigation, giving an overview of the main principles of the Dzogchen Zhangzhung Nyengyü and brief biographies of the lineage figures depicted on the *tsakali*. From the inscriptions presented on the verso sides of the cards, we learn something of the identity of the figures painted on the recto sides, but we do not know when, where or by whom these cards were produced. Further research questions we considered were the following: what materials have been used and did they change over time? Did the usage of the cards change over time? To preserve the heritage object, what is the best conservation treatment and method of storage? The focus of this study lies particularly on the material side, and the nano-structure of the paper and materials used and the techniques of the colourful paintings are of special interest for solving some of the research questions.

To perceive the *tsakali* set as a material object, and to understand it fully, we started with basic information received from Charles Ramble, the owner of the *tsakali* set. We learned that the origin of the collection is unknown, but that the set was said to have been created in Dolpo, in Nepal, before being taken to Tibet, where it was concealed and saved from destruction during the Cultural Revolu-

tion before being brought to the Bonpo monastery of Tritten Norbutse, in Kathmandu, in 1986. We further learned that the set belongs to the Bon religion, in particular to the meditative system known as the Dzogchen Zhangzhung Nyengyü, the ‘Oral Transmission of the Great Perfection from Zhangzhung’. On stylistic grounds, it had been provisionally dated to the fifteenth century, but there was no evidence that could confirm this claim.

The radiocarbon dating results indicate that Tsakali 0 dates to the mid fifteenth century, making it younger than suggested by its stylistic association, while Tsakali D dates to the fourteenth century. This confirms that Tsakali 0 and Tsakali D were produced at different times, with Tsakali 0 having been created at least fifty years after Tsakali D. Based on this information – also confirmed by different numbering systems, as well as art-historical observations on the style of painting – it is most probable that the set is composed of several smaller subsets that were later combined.

Advances in analytical techniques, digital humanities tools, isotope research and social network surveys have revolutionised provenance studies in recent years. However, this line of research requires collecting data for specific regions and times that become references for future work. Owing to the fact that there are not many references for manuscript production in Dolpo, we do not know exactly where this *tsakali* set might have been produced. The paper support of all the cards appears to be typical for the region, but it varies throughout the collection from the technological point of view. This can be explained by the use of different tools: in this case, the papermaking moulds and sieves used for producing the paper. This also may suggest that the paper may have been acquired from different sources, suggesting that subsets may have been produced at different times. The sixty-five cards were in fact made of a very similar, structurally quite homogeneous type of paper, and so far only technological features relating to texture (specifically the type of papermaking sieve) have made it possible to differentiate two types of paper – woven and laid – as described in Chapters 1 and 5. This does not mean, however, that they were produced at the same time.

Microscopic analysis showed that the paper of the *tsakali*, independently of its technological features (both woven and laid), is mostly homogeneous and made of *Stellera chamaejasme*, sometimes with a minor addition of other fibres. This plant is widely distributed throughout the Himalayan range, where it is found on sunny, dry slopes and sandy places at altitudes of 2600 to 4500 m above sea level. However, it has been used as the main raw material for papermaking only in places where other papermaking plants cannot be found, that is, above 3600 m. While this information does not exclude Dolpo as the place of production, it does not allow us to unequivocally identify it as such.

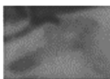
Artificial intelligence tools are most effectively used in the context of large collections, which is why this approach was appropriate for the analysis of the cards, especially since more such cards are preserved in the Triten Norbutse Monastery in Kathmandu. In the future, these may be examined by the same method: a handwriting analysis tool used to identify potentially different scribes, a tool for analysing markings on the paper substrates, and another for the automatic recognition of repeated patterns.

Sometimes the methods were applied independently, but other times in clusters, where one method guided the others. This was the case for multispectral imaging (MSI), which successfully guided further studies of paper and colourants, and also produced the high-resolution, accurate-colour images that fulfilled all the typical needs of archival digitisation, and therefore served as a basis for a palaeographic and art-historical study (see Chapter 3), as well as for computational pattern analysis work (see Chapter 5). The statistical processing of the spectral data with independent component analysis (ICA) produced a number of so-called ‘pigment maps’ that highlighted potential anomalies and thereby guided the initial, otherwise blind, measurements with X-ray fluorescence (XRF) and Raman spectroscopy (see Chapter 9). The infrared transmissive images allowed us to group the cards according to the paper structures that were further explored with microscopy and Fourier transform infrared spectroscopy (FTIR) (see Chapters 1 and 8, as well as the appendix). In such cases, the order of the methodological approaches was also important.

One interesting example of complementary approaches was when, unexpectedly, the infrared reflectance images revealed letters beneath the various colours – a kind of paint-by-numbers system – that offered insight into painting techniques and the *tsakali*’s production methods (art history, context). Kyle Ann Huskin and Ivan Schevchuk (see Chapter 4) made the invisible Tibetan letters beneath the painting visible while performing MSI but then, to fully understand this discovery, we needed to collect further pieces of information as presented in Table 1 below.¹

¹ The colleagues who contributed to understanding the data in Table 1 are Kyle Ann Huskin, Ivan Schevchuk, Lucas F. Voges, Christian Luczanits, Charles Ramble, Nils Martin, Olivier Bonnerot, Sebastian Bosch, Sowmeya Sathiyamani, Sylvio Haas and myself.

Table 1: Colour code key and the substances used to make them based on the combination of MSI, Tibetology, art history, XRF and XRD.

Tibetan letter marker	Transliteration of the letter indicator	Tibetan name of the colour used	Colour	Materials and substances
	K	<i>dkar</i>	white	kaolinite ($\text{Al}_4[(\text{OH})_8 \text{Si}_4\text{O}_{10}]$), limestone (CaCO_3), lead white ($2\text{PbCO}_3\text{Pb}(\text{OH})_2$)
	Ng	<i>sngon</i>	light blue	
	Th	<i>mthing</i>	dark blue	azurite ($2\text{CuCO}_3\text{Cu}(\text{OH})_2$), indigo ($\text{C}_{16}\text{H}_{10}\text{O}_2\text{N}_2$), Prussian blue ($\text{Fe}_4[\text{Fe}(\text{CN})_6]_3 \cdot x\text{H}_2\text{O}$)
	M	<i>dmar</i>	red	cinnabar (HgS), red lead (Pb_3O_4), red ochre ($\alpha\text{-Fe}_2\text{O}_3$)
	S	<i>ser</i>	yellow	gold (Au), orpiment (As_2S_3), realgar ($\alpha\text{-As}_4\text{S}_4$), yellow ochre (mixture of iron-containing minerals)
	Sh	<i>sha</i> lit. ‘flesh’	not a specific colour, but a range of possible colours that are used for human skin	
	J	<i>ljang</i>	green	malachite ($\text{CuCO}_3\text{Cu}(\text{OH})_2$), azurite ($2\text{CuCO}_3\text{Cu}(\text{OH})_2$)
	N	<i>na ros</i>	‘maroonish pink’ (according to Jackson and Jackson 1984; pale pink is a different word)	

The examination of the colour palette of the *tsakali* categorically shows how important it is to combine as many methods as possible to elucidate complex structures. Combining the element-sensitive method XRF with the more crystal structure-sensitive methods of Raman and XRD allows for the investigation of pigments in a more comprehensive way. We believe that the combination of XRF/XRD/Raman mapping of written artefacts, paintings, etc. will result in new insights into cultural heritage objects. Importantly, the low-resolution XRD mapping experiment that

was performed was sufficient to obtain the desired information without the need for performing high-resolution powder diffraction, which would require a small fragment of the colour layer to be extracted from the object and would make the analysis destructive due to the necessity for sampling.

The colour palette of the *tsakali* collection was determined through X-ray diffraction (XRD) pattern analysis complemented by X-ray fluorescence (XRF) scanning and Raman and Fourier transform infrared (FTIR) spectroscopy, which proved to be exceptionally useful when we examined the blue and pink areas of the images. The palette comprises gold, orpiment, malachite, azurite, cinnabar, indigo and a hitherto unidentified pigment phase, designated the 'Tibet phase', which is mixed with the indigo pigment.

It was only through the close collaboration of Sylvio Haas, Olivier Bonnerot, Sebastian Bosch, Sowmeya Sathiyamani and Agnieszka Helman-Ważny that we were able to determine the material used for the blue and pink sections of the images. Evaluating each method together produced a coherent picture, whereas using them individually yielded different results. We identified the material as an unknown phase containing iron and arsenic, which we termed the 'Tibet phase'.²

Thus, one of the important results of this case study is the determination of which integrated methodologies worked best together, based on the effectiveness of examining particular elements or aspects of the object. Some methods more directly complemented each other when applied in a specific order. The methods that can be recommended for studying paper were MSI infrared transmissive images (paper structure, papermaking technology and sieve print); microscopy (fibres and other components); Fourier transform infrared (FTIR) spectroscopy (density of fibres); small-angle X-ray scattering (SAXS) (fibre orientation); and AMS ¹⁴C (independent dating method). Then, the methods that proved to be useful for studying colourants were MSI statistical processing of the spectral data with independent component analysis (ICA); wide-angle X-ray scattering (WAXS) (colourants); X-ray diffraction (XRD); X-ray fluorescence (XRF) scanning; Raman spectroscopy; and Fourier transform infrared (FTIR) spectroscopy, as well as art-historical methods.

The application of such multi-integrated methodologies obviously advances the study through the monitoring and constant verification of individual procedures, especially in the case of novel techniques. Furthermore, a combination of different methods (and control) is especially important in the case of the non-destructive methods, which often need to be confirmed by other analyses.

² For a detailed explanation, see Haas et al. forthcoming.

For example, when attempting to group the paper of the *tsakali* according to the results obtained from different methods, it was clear that each method pointed to different qualities of the paper. It was impossible to understand the overlap of such a classification, as shown in Table 2.

Table 2: Grouping of *tsakali* cards by MSI/technological characteristic and by SAXS.

Grouping by MSI/technological characteristic		Grouping by SAXS	
A Woven paper	B Laid paper	Group A	Group B
Quality A1 without fibre bundles, with ‘cloudy’ fibre distribution	Quality A2 with many fibre bundles	0, 3, 5, 7, 9, 12, 13, 15, 21, 26, 33, 34, 35, 38, 39, 44, 45, 48, 49, 56, E, G, H	1, 2, 4, 6, 8, 11, 14, 16, 17, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29, 30, 31, 32, 36, 37, 40, 41, 42, 43, 46, 47, 50, 51, 52, 53, 54, 55, A, B, C, D, F
1, 2, 3, 4, 5, 7, 8, 9, 11, 13, 15, 17, 19, 21, 34, 56, G, F	6, 8, 12, 14, 16, 18, 20, 22, 24, 26, 27, 28, 29, 30, 31, 32, 33, 35, 36, 37, 38, 39, 40, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 57, 58, H, B, C, E	23, 25, D	

When looking at the backlit paper (grouping by MSI/technological characteristics) of these *tsakali*, both woven and laid papers were identified. Sixty-two (out of sixty-five) cards are composed of the woven type of paper, but reveal two different qualities. Quality A1, woven paper without fibre bundles with ‘cloudy’ fibre distribution, was observed on *tsakali* nos 1–5, 7, 9, 11, 13, 15, 17, 19, 21, 34 and 56, while the slightly rougher-quality A2, woven paper with many fibre bundles, was observed on nos 6, 8, 12, 14, 16, 18, 20, 22, 24, 26, 27, 28–33, 35–40, 42–55 and 57–58. Nos 23, 25 and D were produced on the laid type of paper (Type B). A summary of results is presented in the appendix.

The analysis of the orientation of the cellulose fibrils (grouping by SAXS) permits the classification of the cards in accordance with the similarity of the orientation distribution. The sixty-five cards can be classified into two sub-collections, designated as Group A and Group B, as shown in the table.

The application of Fourier transform infrared spectroscopy (FTIR) in DRIFTS mode was used to analyse the components of the *tsakali* paper. Peaks associated with cellulose, hemicellulose and lignin were detected in the spectra, while no fillers, addi-

tives or sizing could be identified. The paper of the *tsakali* was analysed to determine whether the two main paper types already detected influenced the resulting spectra using principal component analysis (PCA). The results showed that the R3 ratios of the 1735/2925 cm^{-1} peaks revealed a strong separation between high- and low-fibre density papers. This grouping did not, however, overlap with any of the above.

This raises the question: what do these different methods tell us about the paper? First, a technological classification obviously points to different sheet formation techniques. However, it does not overlap with the SWAX analysis of fibril orientation, a novel method that needs to be better understood. This difference may provide further technological or process-related information in the future. In the end, some studies generated more research questions than answers, but did not of course make these cases any less important. As a result, not all the chapters with scientific approaches provided expected and clear information that could lead to firm conclusions about the provenance or nature of the *tsakali* set. This was sometimes due to a lack of reference data (previous material analyses of other *tsakali* sets) that would allow for more accurate interpretation of the data that resulted from this study. In such cases, the results indicated the potential of such research for future studies.

If we were only to apply already established methods, there would be no space left to develop new ones and to make progress. The methods, independently of their direct information sourcing for the object, provided measurements that have the potential to be useful references for future studies of similar types of objects from Tibet and the Himalayas. This is how the integrated methodologies can be developed: by cross-checking new methods that are still under development with those that are more established. It is especially important for developing new non-destructive protocols so they can be verified by methods that are well known and have proved to be useful.

The whole book explains the importance of new insights and opportunities made possible by the availability of new technologies and tools, as well as the interest of scholars from different backgrounds who were working in interdisciplinary team. By broadening the scope of the methods and involving different ways of thinking, we learned more and gained greater precision in the temporal and regional attribution of the *tsakali* set under examination. We had a chance to see for ourselves that when we integrated a scientific protocol with the codicological and textual scholarship that is traditionally applied to manuscript studies, we were able to learn far more and obtain a fuller history of the material object under study.