

The Zhangzhung Nyengyü 'Tsakalis': A Cross-Disciplinary Analysis

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The Zhangzhung Nyenggyü ‘Tsakalis’: A Cross-Disciplinary Analysis

Edited by
Agnieszka Helman-Ważny

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Khenchén Tenpa Yungdrung Rinpoche

Preface

Yungdrung Bon, the ancient religious tradition of Tibet and the Himalayas, represents a distinct and enduring spiritual system with a rich historical and doctrinal foundation. Attributed to its founder, Buddha Tönpa Shenrab Miwoche, Bon encompasses a comprehensive framework of teachings known as the Nine Ways of Bon (Bon Thegpa Rimgu), each addressing the diverse capacities and spiritual inclinations of its practitioners. Within this schema, Dzogchen (Dzogpa Chenpo), or the Great Perfection, is revered as the ninth and most profound path.

The first four of the Nine Ways primarily emphasise ritual and practical methods designed to promote the temporal well-being of sentient beings. These include disciplines such as divination, astrology, healing, traditional medicine, prosperity rites, longevity practices, and rituals and means for supporting the dying and the deceased. Deeply integrated into the fabric of everyday life, these practices have been transmitted and preserved across generations in various forms throughout the communities and institutional traditions of Tibet and the greater Himalayan region.

In contrast, the remaining five Ways of Bon are oriented toward the attainment of higher spiritual realisation. These comprise the path of renunciation, focused on monastic discipline; the path of transformation, characterised by tantric methods; and the path of liberation, centred on the advanced yogic meditation practices of Dzogchen. The transmission of these teachings occurs through three principal modalities known as the Three Streams of Transmission: Wang (empowerment), Lung (textual or reading transmission), and Tri (instruction – both theoretical and experiential). Full reception of these three components is essential for the authenticity and continuity of the practice, particularly for those who hold the responsibility of conferring teachings and transmissions. According to established lineage protocols, for instance, a teacher who has not personally received the Lung or Wang of a particular cycle from a qualified lineage-holder is not authorised to transmit them to others.

An expanded dimension of ritual practice in the Bon tradition involves the use of a diverse array of sacred objects and substances, each imbued with symbolic and ritual significance. These implements are intentionally acquired and carefully preserved by practitioners, often passed down over generations, serving as supports that sustain the efficacy and authenticity of the practice. Among these ritual supports are *tsakali* – miniature painted cards or icons – used in visualisation, empowerment and protection rituals.

The present volume focuses on a unique set of *tsakali* associated with the Zhangzhung Nyengyü cycle of Dzogchen teachings, a lineage preserved within the Kama tradition of oral transmission. Unlike Terma (Revealed Treasures), which are discovered texts often concealed for future revelation, the Zhangzhung Nyengyü has been transmitted in an unbroken line from teacher to disciple over centuries.

This study, edited by Agnieszka Helman-Ważny, represents a pioneering interdisciplinary investigation into these rare and culturally significant objects. Through the integration of textual and iconographic analysis with material science methodologies – including the examination of paper, pigments, ink and script – the work offers new perspectives on the historical and ritual functions of *tsakali*. This innovative approach bridges important gaps in the study of Tibetan material culture and contributes meaningfully to our broader understanding of the religious, artistic and intellectual history of Tibet and the Himalayas.

I extend my sincere appreciation and congratulations to the authors for these scholarly contributions, and I recommend this volume to all those engaged in the study of Tibetan religions, art history, material culture and cross-disciplinary research. It is my hope that this work will inspire further inquiry and offer valuable insight into one of the world's oldest and most complex spiritual traditions.

Khenchen Tenpa Yungdrung Rinpoche
Shenten Dargye Ling, France
18 April 2025

Introduction

The present research aims to recover the little-known history of the production and usage of a collection of *tsakali* (ritual cards) belonging to a Tibetan spiritual system called Zhangzhung Nyengyü (the ‘Aural Transmission from Zhangzhung’), including the cards’ provenance, dating, and the specific techniques and technologies used in producing them. Further, we may also uncover what such a personal ritual object might tell us about the student–master relationship, teaching method and the people to whom this set belonged. In this way, our ‘complete history’ of these cards takes the form of a holistic research approach placing the material object at its centre, exploring the creative process from idea to artefact and connecting the object with the rituals and people who used it.

The book consists of an introduction, ten short chapters, an epilogue, and a handlist with an image catalogue presenting the recto and verso sides of the *tsakali*, as well as transcriptions and translations of their inscriptions and selected material features, such as paper and colourants. Each chapter presents the results obtained by particular disciplines and methodologies individually and independently of each other. The methods used are briefly described and the preliminary results of each study are presented and discussed; our complete history of the Zhangzhung Nyengyü *tsakali*, founded on the basis of these investigations, is presented in the epilogue.

Tsakali (*tsa ka li*) collections are among the main material objects used in Tibetan ritual, but they are not very widely known due to their specialised and private use. Whenever they feature in collections, it is always the rarity of this type of object that is emphasised. Further, their dating is often unclear, especially since such collections are usually composed of a number of other items resembling each other in form, though not necessarily produced at the same time, and used in different configurations. The most common questions that arise whenever a new set is presented are the following: to which tradition does the 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 owed them?

Due to the complexity of this type of object, these seemingly basic questions are not at all easy to answer. This is why, when Charles Ramble offered to make his collection of *tsakali* available for material analysis, I willingly accepted the challenge. I was especially interested in carrying out the investigation as there were no previous systematic studies of such objects, nor any cross-disciplinary

investigations of the materials these objects are made of. Furthermore, it was immediately possible to see that the set, composed of sixty-five Tibetan illuminated cards, was a rare fine-art piece, in addition to having obvious cultural value as a ritual object belonging to the Tibetan tradition.

At the material level, the *tsakali* consist of various elements – such as written text and images – produced with different materials: paper, ink and paint, with all of their basic components and intrinsic qualities. Depending on the magnification used to look at the object and its components, different areas of expertise and equipment are required to study them. Exploring the material composition of the object may provide important information about its production process, provenance, and use and reuse. For example, in the *tsakali* set examined here, the text consists of names written with red ink on the recto sides of the cards, inscriptions written in black ink on the verso sides, and numbers added later in blue ink. The images feature figures or ritual paraphernalia enclosed in frames on the recto sides of all cards. Further material components include pigments mixed with binding media (paints) and the techniques applied to the paint, as well as the iconography and style of the illuminations. The paper used as a support for the images and writing is made of various raw materials, such as plant fibres, glue and possibly other substances that may not always be detectable by scientific analysis. To understand the materiality of the object under study, besides these materials, we also need to consider the technology used in the production process. A complex programme of investigation was developed in order to address the complexity of this object.

The study presented here is based on a cross-disciplinary investigation conducted by the members and collaborators of the Cluster of Excellence ‘Understanding Written Artefacts’. This investigation combines methods adapted and developed from a range of both science and humanities-oriented disciplines, driven by the idiosyncratic character of this particular object and its Tibetan context. Besides codicological, historical, anthropological and art-historical considerations, the framework of this study includes the pattern analysis of digitised images, as well as the application of advanced material-analysis techniques in order to analyse various physical and chemical aspects of this handwritten ritual artefact.

Our study starts with a general presentation of the *tsakali* set in the context of its social history, artistic and cultural affiliation. *Tsakali* such as these are widely used in the rituals of both Bon and Tibetan Buddhism. They are usually produced as thematic sets whose number of cards may range from one to several hundred, and they are very difficult to understand outside of their ritual context. Thus, in Chapter 1, ‘*Tsakali* Illuminated Cards: Physical Description, Function and Context’, by Charles Ramble, Christian Luczanits and myself, the Zhangzhung Nyengyü

tsakali set is presented as a physical written artefact based on a first visual assessment, undertaken with the naked eye and simple optical tools that can easily be used in the reading room of any library. The chapter provides basic catalogue and codicological information, such as size, form and condition; the type of language, script, illustrations and textual content; and initial macroscopic observations on the materials and technological features, retrieved by Dino-Lite digital microscope or with the naked eye. A handlist of the *tsakali* with the transliterated and translated text of the inscriptions, as well as further information on the materiality of the cards, is included in the appendix at the end of the volume.

There are many ways in which manuscripts can be studied. Usually, the approach depends on the educational background of the researcher in question and the discipline she or he represents. This means different approaches are followed, with different methods and tools used depending on the angle from which the research is undertaken. Traditionally, however, Tibetan material objects have been studied by scholars of the Tibetan language, who had the skills to understand the Tibetan text written on the object as well as its contextualised meaning. This is why we have started our investigation with the inscriptions on the cards and the historical context of the collection.

In Chapter 2, ‘The Teachings of the Dzogchen Zhangzhung Nyengyü System and Their Transmission’, Charles Ramble explains the meditative system known as the Dzogchen Zhangzhung Nyengyü, the ‘Oral Transmission of the Great Perfection from Zhangzhung’, to which our set of *tsakali* belong. It is principally members of the Zhangzhung Nyengyü transmission lineage who are depicted on the cards. Following a presentation of the main principles of the Dzogchen Zhangzhung Nyengyü system, this chapter offers brief accounts of the lives of the lineage members who are depicted on the *tsakali*.

The focus on the text in this study, though obvious, is only the starting point. The *tsakali* set is in fact both a written artefact as well as an object of art, as it contains extensive painting on the recto side of each card. Moreover, painting is a major element of this special ritual object. In addition to being examined by a specialist of Tibet, such an object should therefore be examined by a specialist trained in both Tibetan studies and art history.

In Chapter 3, ‘Art-historical Analysis of the *Tsakali* Collection’, Christian Luczanits discusses the set from an art-historical perspective, considering the derivation of its style and the basis of its iconography compared with those of portable paintings and murals from across the Himalayas. Besides the actual date of the set and its different parts, its potential place of manufacture is also assessed. This discussion is crucial to understand the complexity of such objects. At first glance, the set appears largely consistent and painted in a style most com-

monly associated with the fourteenth century. Luczanits also shows that when one looks at specific details, certain elements of the figures – such as the lower garment of the Buddha's dress – may indicate a somewhat later date. Issues of dating are also discussed in Chapter 2 and Chapter 10.

Tibetan written artefacts become objects of scientific examination when they eventually find their way into museum collections, and it is only in recent decades (for example, following the development of preservation as a scholarly discipline) that Tibetan written artefacts have been studied as both material and textual objects. The materiality of these objects, together with the technologies behind their production, have received greater attention in recent times due to growing interest in the cultural production and indigenous knowledge preserved within Himalayan communities.

When discussing the materiality of Tibetan written artefacts, one should be aware that they represent a topic that requires an interdisciplinary approach and precise definitions for the concepts and elements of the Tibetan cultural realm. Such a cross-disciplinary approach has been promoted in recent decades by the Cluster of Excellence 'Understanding Written Artefacts' (UWA) at the Centre for the Study of Manuscript Cultures (CSMC), which aims to investigate the rich diversity of global manuscript cultures in terms of their material objects. One of the most useful non-destructive methods of research applicable to the study of written artefacts is multispectral imaging (MSI), discussed in Chapter 4, 'Multispectral Imaging (MSI) and Statistical Image Processing to Analyse Pigment Distribution and Diverse Material Features', by Kyle Ann Huskin and Ivan Shevchuk.

The authors report on the use of this non-destructive and non-invasive method, which is the most advanced approach for recovering erased, palimpsested or otherwise obscured text. The technique can also easily facilitate many different avenues of research, and here it has been applied to the *tsakali* with this goal in mind. MSI produces a diverse set of images with a decent spectral resolution and very good spatial resolution. Statistical processing of the reflectance and fluorescence images produced a kind of pigment map, for instance, which guided subsequent material analysis using XRF and Raman spectroscopy. The transmissive images revealed the substrate's fibre structure, revealing anomalies to be explored with paper analysis techniques. MSI also produces high-resolution, true-colour images that fulfil all the typical needs of archival digitisation; these images served as the basis for the handwriting style and pattern recognition analysis discussed in Chapter 5, 'Analysing the Visual Patterns of the Zhangzhung Nyengyü *Tsakali* Collection Using Machine-Learning Approaches', by Hussein Mohammed and Agnieszka Helman-Ważny.

The collection was given to Charles Ramble by Lopön Tenzin Namdak Rinpoche, a Tibetan religious leader and teacher of the Bon tradition. The sixty-five cards were originally a part of a larger set or sets that were concealed during the Cultural Revolution in China, when many monastic libraries were destroyed and many books burned. Tenzin Namdak Rinpoche believed that the collection might have been produced in Dolpo, but he was uncertain about this. The collection was not dated, and no other provenance information was provided apart from the accounts of the lineage members who are depicted in the *tsakali*, discussed in Chapter 2. The remaining cards, representing the lineage masters of the two other main Dzogchen systems of the Bon religion, are now preserved in the Triten Norbutse Monastery in Kathmandu, Nepal. When Khenchen Tenpa Yungdrung Rinpoche, the abbot of the Triten Norbutse Monastery, was asked whether the sixty-five *tsakali* formed a set of their own and whether this set differed from others, he answered that they all belonged to the Bon Dzogchen tradition, and that they were all of the same quality, materials, style of painting, purpose and even dimensions. This would mean that the full set may contain a couple of hundred cards, from which sixty-five were selected to offer to Charles Ramble due to his particular interest in the Zhangzhung Nyengyü system. Thus, this study may in the future be expanded to cover the remaining collection in Kathmandu.

Keeping in mind that the full set is much larger than the sixty-five cards examined here, several visual pattern analysis and computer vision methods have been applied to the digital images of this collection. This investigation demonstrates the potential of these machine-learning approaches and their applicability to manuscript research. Furthermore, the results of these computational methods can be used as supporting information in the decision-making process for several research areas, such as paper analysis, art-historical research, identification of scribes, and others.

In Chapter 6, ‘Multiscale Microscopic Analysis of the Paper and Fibres of the *Tsakali*’, Agnieszka Helman-Ważny discusses the results obtained by the use of both digital and optical microscopy to study the raw materials composing the paper of the *tsakali*. Fibre analysis tells us what the *tsakali* paper is made of, since the primary feature of paper is the type of raw material used in its production. The ability to distinguish separate plant species in paper fibre is why fibre analysis, if and when applicable, is helpful in locating regional origin and sometimes in dating, especially when using a comparative study that entails overlapping typologies. Other aims were to learn about the relationship between the raw materials and the properties of the resultant paper, and to deduce the origins of the paper by comparing the fibre identification results with local occurrences of the same plant. At the methodological level, this study also discusses the possibilities and

limitations of different types of microscopes in the characterisation of the fibres and other components of the paper, as well as the potential contribution of such research to the provenance study.

In Chapter 7, ‘The Application of Small- and Wide-angle X-ray Scattering to the Study of the Paper Support and Pigment Distribution’, by Sylvio Haas and Agnieszka Helman-Ważny, discusses how information about the local nano-structure can be obtained from X-ray scattering signals. The focus of this study was to develop a protocol to identify the resemblances in the paper composition of each card. At the same time, the characterisation of the *tsakali* paper contributed to the development of an innovative experimental X-ray scattering-based approach to complement current analytical methods of antique paper identification and raw material characterisation.

Chapter 8, ‘Analysis of Paper Components with FTIR (DRIFTS) Spectroscopy’, by Claudia Colini, Lucas F. Voges and Stephan Seifert, discusses the application of Fourier transform infrared spectroscopy (FTIR), independently of microscopy, to study the *tsakali* paper components, especially for the identification of fillers, sizing agents and degradation processes. Previously, it has also been used for fibre identification, although the presence of different sizes and of multiple types of fibres in the same object might compromise the results. This method is based on the excitation of chemical bonds in a molecule by IR light with characteristic frequencies, resulting in specific types of molecular vibrations. These vibrations are detected and recorded in spectra: the position and intensity of the peaks provide information about the chemical composition and crystalline structure or geometry of the molecule. Comparing reference spectra to those of unknown substances proved extremely effective for their identification. Furthermore, chemometric approaches like principal component analysis (PCA) will be applied to fingerprinting. PCA generates new variables (principal components) that represent the main variances of the spectra and, hence, can be used to analyse the similarities and differences between them.

In Chapter 9, ‘Multi-instrumental Analysis of Pigments and Dyes’, Sebastian Bosch, Olivier Bonnerot and Sowmeya Sathiyamani report on various instrumental analyses applied to study a wide range of different colourants found in the *tsakali*. These are paints based on mineral pigments, dyes derived from plants, or mixtures of these. A map of pigments from the multispectral data prepared by Ivan Shevchuk and Kyle Ann Huskin is used as a starting point for further non-invasive analysis with XRF, VIS and Raman, as discussed here. The XRF measurements taken from four different panels of the manuscripts are compared with a view to identifying these colourants.

In Chapter 10, ‘Radiocarbon Dating of *Tsakali* Paper’, Tomasz Goslar and Agnieszka Helman-Ważny discusses the possibilities and limitations of radiocarbon AMS dating methods for the *tsakali* collection. It offers a good reference point, as its method is independent of all other methods.

Differences between the approaches of the humanities, hard sciences and computational sciences, apart from the different methods and expertise involved, also emerge from the scale at which the object is approached. On the macro scale, it is mainly content, such as text and illustrations, that is studied, or codicological features such as layout, format and materials at the general level. To access more detailed information, one needs to look at the object on a micro scale in order to study its materials. This requires all kinds of microscopy, from a standard optical microscope to large X-ray facilities such as synchrotron. Scale level is crucial, as we can identify different features at different magnifications. For example, with the digital Dino-Lite microscope, we can observe the texture of paper, techniques of painting and writing, order of layers, and sometimes some other features of the surface.

More humanities-related approaches, by contrast, usually consider the object under study as a single unit. For example, translations, transcriptions and other text analyses are done in the context of the whole object that needs to be read. When considering material analyses, techniques like digital microscopy make it possible to study the whole object, even though observations are necessarily limited to smaller selected areas due to the length of time required for such observations or the costs associated with the use of high-performance lab equipment. Producing large amounts of repetitive data, for example from microscopic observations, is not always necessary to conclude analyses with successful identifications of specific materials. This is why every study usually starts with the most representative parts or points of the object. In our study, depending on the specific research questions, we first discuss the possibilities and limitations of every method before developing the protocol that was later applied rigorously to the selected *tsakali*. Table 1 below presents a list of all the *tsakali* and the methods used to study them.

An important question that should be raised here concerns the extent of the research that has to be planned to be representative of an object or a collection. In the present case, our object is the set composed of sixty-five different cards. If we were to perform material analyses on each individual card, many years would be required to complete the study. While the examination of each card is necessary for macroscopic observations, it would be impossible for other procedures, for example synchrotron-related techniques, and other sophisticated methodologies that would require a far greater investment of time and resources. The limitations also come from the assessment of whether it is possible to sample the object for material analysis.

Table 1: Selection of *tsakali* for study by particular methods.

Original <i>tsakali</i> no. and name	Inscription (see Ch. 2)	Paper technology (see Ch. 1)	Paper fibre analysis (see Ch. 6)	Art history (see Ch. 3)	MSI (see Ch. 4)	Pattern and line detection (see Ch. 5)	X-ray scattering (see Ch. 7)	FTIR (DRIFTS) spec- troscopy (see Ch. 8)	Multi-instrumental (see Ch. 9)	¹⁴ C (see Ch. 10)
0 Bum pa (vase)	x	x	x	x	x	x	x			x
1 Ye nyid kyis ston pa	x	x	x	x	x	x	x		x	
2 Thug[s] [b]rtse'i ston pa	x	x	x	x	x	x	x			
3 Cir yang sprul pa'i ston pa	x	x	x		x	x	x	x	x	
4 Tshad med 'od ldan	x	x	x	x	x	x				
5 Yab 'Phrul gshen snang ldan	x	x	x		x	x				
6 rGyud khungs kyi ston pa	x	x	x		x	x	x			
7 Yum Zang za rig btsun	x	x	x		x	x		x		
8 Sras 'Chi med gtsug phud	x	x	x		x	x	x	x		
9 gShen gSang ba 'dus pa	x	x			x	x				
11 Klu bon Pha nam skyol po	x	x		x	x	x				
12 Mi bon Khri lde zam bu	x	x		x	x	x	x			
13 Zhang zhung Nam skyol po	x	x			x	x				
14 Sras khri shod rgyal ba	x	x			x	x				
15 Ra sang bsam grub	x	x			x	x				
16 Sras Dar ma shes rab	x	x		x	x	x				
17 Sras Dar ma Po de la	x	x			x	x				
18 Zhang zhung khri 'phan la	x	x			x	x				
19 Mu ye lha rgyung	x	x			x	x		x		
20 rMa gshen leg[s] bzang	x	x			x	x				
21 Sras sTag la	x	x			x	x				
22 Ra sangs g.yung drung	x	x			x	x				
23 De sras g.Yung 'phan	x	x			x	x	x	x		
24 dGe 'bar don grub	x	x			x	x				
25 De sras dGe 'phan	x	x			x	x	x	x	x	
26 De sras dGe' rgyas	x	x			x	x				
27 Zhang zhung rNam rgyal	x	x			x	x				
28 Mu rgyung dkar po	x	x			x	x				
29 Hor ti chen po	x	x			x	x				
30 Don grub pa	x	x			x	x				
31 Ra sangs 'phan rgyal	x	x			x	x				
32 Ku [Gu] rib gsas rga	x	x		x	x	x				

Original <i>tsakali</i> no. and name	Inscription (see Ch. 2)	Paper technology (see Ch. 1)	Paper fibre analysis (see Ch. 6)	Art history (see Ch. 3)	MSI (see Ch. 4)	Pattern and line detection (see Ch. 5)	X-ray scattering (see Ch. 7)	FTIR (DRIFTS) spec- troscopy (see Ch. 8)	Multi-instrumental (see Ch. 9)	¹⁴ C (see Ch. 10)
33 Zla ba rgyal mtshan	x	x			x	x				
34 Ta pi hri tsa	x	x			x	x				
35 sNang bzher lod po	x	x			x	x				
36 rGyal gzigs gsas chung	x	x			x	x				
37 dMu' gshen tso ge	x	x			x	x				
38 dMu gshen tso stang	x	x			x	x				
39 Sho gram chen po	x	x			x	x				
40 rGyal ba blo gros	x	x			x	x				
42 Gu ge blo ldan	x	x		x	x	x				
43 Pu rang kun dga'	x	x			x	x				
44 rNal 'byor gsas mchog	x	x			x	x				
45 Khyung 'byid mu thur	x	x			x	x				
46 bDe ba ring mo	x	x			x	x				
47 rTog med zhig po	x	x			x	x				
48 lHun grub mu thur	x	x			x	x				
49 gShen rgyal	x	x			x	x		x		
50 rNgos grub rgyal mtshan	x	x			x	x				
51 Bla ma kun 'dul	x	x			x	x		x		
52 Yang ston chen po	x	x			x	x				
53 Dam pa 'bum rje	x	x			x	x				
54 bKra shis rgyal mtshan	x	x			x	x				
55 Ye shes rgyal mtshan	x	x			x	x		x		
56 rGyal mtshan rin chen	x	x			x	x				
57 Ngang pa shes rab	x	x			x	x				
58 Bla ma rgyal mtshan	x	x			x	x				
A Zhing lnga gtso' bo	x	x	x	x	x	x	x		x	
B gSang ba 'dus pa	x	x	x	x	x	x	x	x		
C lCe rgyal bar ti	x	x	x		x	x		x		
D gSang ba ngang ring	x	x	x		x	x	x	x	x	x
E Mu cho ldem drug	x	x	x		x	x		x		
F Ti sang rang bzhin	x	x	x		x	x		x		
G Chag med ye shes g.yung drug	x	x	x	x	x	x		x		
H rKo'o Ye shes rgyal mtshan	x	x	x	x	x	x		x		

Agnieszka Helman-Ważny, Charles Ramble, Christian Luczanits

Chapter 1: *Tsakali* Illuminated Cards: Physical Description, Function and Context

Abstract: In this chapter, the Zhangzhung Nyengyü *tsakali* set will be presented as a physical, written artefact based on a preliminary visual assessment, undertaken with the naked eye and simple tools that can easily be used in the reading room of any library. Basic catalogue and codicological information will be provided: size, form and condition; the type of language, script, illustrations and textual content; and initial macroscopic observations on materials and technological features, retrieved with a Dino-Lite digital microscope. The set will be described on a comparative basis and in the context of its social history and artistic and cultural affiliation.

1 *Tsakali* as heritage objects

There are two common translations for *tsakali* (Tib. *tsa ka li* or *tsakli*) in the existing literature: ‘miniature painting’¹ and ‘initiation card’. While the former stresses their miniature size, the latter emphasises the function of such miniature paintings that come in sets.

It is therefore questionable whether all paintings published under the term *tsakali* should be designated as such. For example, the earliest object likened to a *tsakali* is from Dunhuang (The British Library IOL Tib J 1364),² but it seems that this two-sided painting on a stick is a different type of ritual object. Equally, *tsakali* have to be distinguished from *sādhana* collections, such as the four volumes comprising 510 paintings preserved at the Völkerkundemuseum der Universität Zürich.³ Although similar to *tsakali* in format, these specific paintings are based on a print from Narthang and do not entail specific rituals.

The following account, then, largely focuses on the initiation cards that accompany ritual practice in both the Buddhist and Bon religions. *Tsakali* are associated with Tibetan culture, but are occasionally also affiliated with Naxi or other non-Buddhist religious systems.

1 Dagyal 1977, 41.

2 van Schaik 2016, 230; Doumy 2017 or Doumy 2023.

3 Willson and Brauen (eds) 2000.

Dan Martin notes on his blog that the word *tsa ka li* is found in certain Kanjur and Tanjur texts, and is a transcription of an Indic term that has never been identified.⁴ This statement somehow reflects how little has been written about the historical origins of this category of object. So far, they have mostly been considered in the context of exhibitions as representatives of much larger sets that are dispersed across many collections.

Though the historical origins of *tsakali* are not clear, their emergence parallels that of Tibetan scroll paintings (*thangkas*), with rare examples potentially predating 1200 CE, but the first large collections datable to the thirteenth century. The earliest datable published examples are traced to the thirteenth to fifteenth centuries, but *tsakali* have become popular in Mongolia as well, where they continue to be produced.⁵ Further, it is notable that while earlier sets of initiation cards are largely figurative, later sets include a wide variety of imagery.

A group of early *tsakali*, painted in what is termed the eastern Indian painting style (*shar bris*), derive from a Taklung school context and can be dated between 1266 and 1297 on the basis of the dedication on their backs. The borderless cards are of two main types: red and black ink on a gold background, or red and gold on a red background. Sixty-six of them are included in a recent study on Taklung painting.⁶ It is clear from their content, mainly teacher portraits and deities, that these were part of much larger sets. For example, among the gold-background paintings are Rāhu and two constellations personified as goddesses, and among the red-background paintings are what were probably two distinct groups of twenty-one Tārās: one group of wrathful Tārās, all of which share the same iconography,⁷ and another group following the tradition of Sūryagupta, with a different iconography for each form.⁸ Furthermore, there is also some variation in size, which indicates that they were not meant to be kept in a stack. As Jane Casey points out, there is some indication that these cards were once consecration con-

4 Martin 2024.

5 As with *thangkas*, the market context from which many of the published examples derive favours earlier examples and the earliest possible dates. A more complete picture can be gained from the pages on initiation cards, Himalayan Art Resources, <<http://www.himalayanart.org/>> (accessed on 1 September 2024).

6 Casey 2023, 928–1040. The final three examples are painted in colour in at least two different styles, and thus do not belong to the two types referred to. Five of this group have been the subject of a study by Amy Heller (1997), with three of those in the Newark Museum collection (Reynolds 1999, 237–239).

7 Casey 2023; *Tsakali* 30–46.

8 Casey 2023; *Tsakali* 49–54. It is likely that, based on their number, the first group also represents the twenty-one Tārās. Casey (2023) does not attempt to identify the Sūryagupta forms individually.

tent, that is inserted into an image or stupa as part of its consecration.⁹ The same applies to a somewhat later set of paintings at the Victoria and Albert Museum that was found within a 41.9 cm high gilt Buddha image.¹⁰ In this case, some of the paintings are larger than others, and it is unclear if any of them is inscribed on the back. Thus, initiation cards can be used as part of the consecration content of images or *chörten* (*mchod rten*), although we cannot be sure that they were originally made for this purpose.¹¹

For two early sets of *tsakali*, both described by Amy Heller, radiocarbon dates of the paper are available. Three paintings from the Roncoroni collection depicting female protective deities (*ma mo*) are painted on paper dated to between 1175 and 1250.¹² Likewise, the paper of another set, now at the Rubin Museum of Himalayan Art, has been carbon-dated between 1174 and 1293 CE.¹³ Stylistically, these Rubin Museum paintings are rather puzzling and indicate a more recent date.¹⁴

While the sets mentioned so far are fragmentary, a complete *tsakali* set is kept in the Metropolitan Museum of Art under the accession nos 2000.282.1 to 2000.282.25.¹⁵ Attributed to the early fifteenth century, this set is dedicated to the deities of the Vajraguhya mandala. Fig. 1 shows the mandala deities with the cards in their relative positions to one another, as can be deduced from the respective colours of the figures. The two dark blue deities above are the primordial Buddhas Samantabhadra and Vajradhāra, while the six figures below are those that appear in the six realms of rebirth, each in the guise of their respective realms. As is commonly the case, the cards' different states of wear suggest that some were more exposed than others.

9 Casey 2023, 928–933.

10 Search for 'IM.121-1910' on <<https://collections.vam.ac.uk/>> (accessed on 1 September 2024) for the Buddha image along with some of the paintings found inside it in the early twentieth century. Adding a letter of the alphabet immediately after '121' reveals further images of this set. The set on the Himalayan Art Resources site, <<https://www.himalayanart.org/search/set.cfm?setID=5492>> (accessed on 1 September 2024), is more comprehensive, but also incomplete.

11 The repetition of the same subject multiple times may be an indicator of some of the illuminated cards' being used as consecration content.

12 Heller 2010, 73–74. Obviously, the date range provided in the article is not the actual radiocarbon date, which comes with a percentage and a margin of error.

13 See Himalayan Art Resources, 'Initiation Cards: Nyingma Lineage Card Set', <<https://www.himalayanart.org/search/set.cfm?setID=120>> (accessed on 1 September 2024). Dates are provided for the individual paintings. Curiously, these somewhat larger paintings are painted on double sheets of paper that were glued together, as is most clearly visible on their versos.

14 This set compares to the one that is the focus of this book in the awkward way that beards of the figures are drawn (see Christian Luczanits's contribution).

15 Van Dyke and Campbell 2015; Behrendt 2015.



Fig. 1: *Tsakali* set with the deities of the Vajraguhya mandala; Tibet, early fifteenth century; opaque watercolour on paper; each painting 6¼ × 5¾ in. (16 × 14.5 cm), New York, NY, Metropolitan Museum of Art, Rogers Fund, 2000 (2000.282.1). Photo in the public domain; arrangement of deities proposed by Christian Luczanits.

As stated above, later collections tend to be more diverse. A good impression of this diversity is reflected in the Himalayan Art Resources site's collection of recent paintings on the subjects of the *Treasure of Precious Revealed Treasures* (*Rin chen gter mdzod*).¹⁶ A notable Mongolian *tsakali* collection is the c. three-hundred *tsakali* collected by Hans Leder in the area of Erdeni-zu Monastery, today held in European collections.¹⁷

These *tsakali* collections can be of any size, from a few cards to hundreds. Preserved sets often range from twenty-five to more than three-hundred. Today, only a careful consideration of their workmanship, material and size allows us to conclude whether cards of a present-day set were originally meant to be used together. Often the numbers indicate only how many of the cards were preserved, and this number may be accidental, especially if a particular set of *tsakali* was used by more than one person. The large number of these objects that have been preserved may indicate a high demand for such images and their common use in ritual and daily practice.

As the examples above already demonstrate, initiation cards are made with a wide range of materials and vary considerably with regard to artistic quality. Some show evidence of sophisticated workshop production and high-quality materials, while others are rather low in quality. The quality of a set is determined by who ordered the set and the artist or workshop that made it. The choice of materials was probably also dependent on what was available at any given time and place. Each set of *tsakali* could have been ordered for a specific person or ritual, but it could also have been produced for personal use by practitioners. The cards are ritualistic in nature, and not primarily intended to be decorative. Their function has absolute priority over aesthetic considerations. Nevertheless, some sets, such as the collection examined in this study, were carefully executed, and beautifully drawn and painted.

According to Khenchen Tenpa Yungdrung Rinpoche, a set of *tsakali* can be manufactured from any kind of paper or material that is not especially poisonous. In the case of a *tsakali*, a thangka or any other kind of image or print, a paper or cloth support is first prepared. This is then usually treated with a mixture of medicinal substances such as the 'six excellent ones' (*zangdruk* or *zangpodruk*, *bzang po drug*), immersed in water with a binding agent. The treatment may be understood as a purification, intended to avoid ritual pollution. For any kind of religious

¹⁶ See Himalayan Art Resources, 'Initiation Cards: Rinchen Terdzö Master List', <<https://www.himalayanart.org/search/set.cfm?setID=1924>> (accessed on 1 September 2024). Each of the volume links leads to a set of *tsakali* relating to it.

¹⁷ Valente de Andrade 2007; Czaja 2013.

object (not only paintings), it is necessary to use the best-quality materials. However, it is often emphasised by Tibetan masters and practitioners that it is not always possible to fulfil this requirement. When high-quality materials cannot be obtained, any kind of paper or other material may be used.

The cards could be drawn or painted on either paper or canvas, or both as in the case of the *tsakali* preserved in the Drangsong collection.¹⁸ More recent cards may also be printed, since printing technology allowed for cheaper manufacturing; printed *tsakali* could be coloured in later if desired. Sometimes they might have been drawn ad hoc in a very simple way, as long as the practitioner was able to associate the image depicted with the practice required. When made of paper, the cards are usually composed of glued layers, in a similar way as Tibetan book leaves.

Typically, the recto side may bear a brief caption indicating the identity of the object or personality featured; the verso, which is not illuminated, will contain a stanza of praise to the subject. Either the recto or verso side, or sometimes both, will bear a number or letter, since the sequence of cards is an important feature of such collections. The depictions on the recto side of each card represent an object, a set of objects or, more commonly, a divine or human personality that is associated with the tradition in question. The great majority of such collections represent the historical figures constituting the spiritual lineage along which its teachings were transmitted, while the deities are those that the practitioner should invoke and visualise in the course of the ritual performance.

If we include miniature paintings, the themes chosen may include the entire Buddhist or Bon pantheon and ritual realm. A good illustration of this wide thematic scope is the Leder Collection, described by Olaf Czaja.¹⁹ It is difficult to differentiate them from painted scrolls (*thangkas*), with the size often being cited as the decisive factor.²⁰ In terms of materials, *thangkas* are usually made on textile with elaborated brocade or silk frames, while *tsakali* are usually much smaller in size and have a simple border framing the figures or symbols in the painting.

¹⁸ Helman-Ważny and Ramble 2023.

¹⁹ Czaja 2013.

²⁰ Several studies indicate a maximum of 20 cm in height.

2 *Tsakali* as ritual objects

Tsakali are employed in numerous ritual situations such as initiation ceremonies, empowerment rites, ritual mandalas or transmissions of teachings. The cards may substitute the ceremonial items they depict, help in visualisation, delimit sacred space or serve as aids to transfer the consciousness of the deceased during funeral rituals. They are used in initiation rituals to empower neophytes in the particular domain of religion they represent. As a tool for passing knowledge from master to student, any given set may well have been designed and produced specifically for a person at a particular level of spirituality. It is also possible that certain cards may have been produced later as the learning process continued.

Cards of the same set often reflect different states of preservation, and it is immediately possible to see which cards were used most often. Thus, if the owner of a particular set is known, we can discern which practice he was most often involved in. A *tsakali* set may provide a visual summary of a regular practice. We may ask how private these sets were: were they used by one master, were they inherited, and were they used by many students?

Many ritual performances entail the recitation of the names of the members of the lineage, and, during the performance, the officiating lama may hold up the images of each figure as the corresponding name is recited. Tibetan Bon and Buddhism are for the most part esoteric traditions, and disciples are not permitted to engage in a ritual or meditative practice, or even so much as to read the accompanying texts, without having first been initiated into the system. It is in the context of such initiation or ‘empowerment’ rituals that *tsakali* are most commonly used. At a certain point in the procedure, the master will touch the disciple’s head with the stack of *tsakali* to signify that he or she is now an authorised inheritor of the spiritual teachings they embody.

The great majority of such collections depict the historical figures constituting the spiritual lineage in which its teachings were transmitted, while the deities are those that the practitioner should invoke and visualise in the course of the ritual performance. Typically – as in the case of the collection considered here – the recto side may bear the polychrome image of a divinity, saint or sacred object, as well as the card index number, and, on the verso side, a passage of text of varying length quoting a scripture related to the corresponding image. The recto side may also bear a brief caption indicating the identity of the object or personality featured. From the text included on the *tsakali*, we can learn something about the identity of the figures painted on the recto side, but this does not tell us when, where or by whom the cards were produced.



Fig. 2: Recently made *tsakali* featuring minor protective divinities called the ‘four sentinels’ (*kha srung bzhi*) being used in a vampire-subjugation (*sri gnon*) ritual in Kagbeni, Nepal (2010).

According to Khenchen Tenpa Yungdrung Rinpoche, collections of *tsakali* are still widely used nowadays during initiations and other important ceremonies (see Fig. 2). He gives the following explanation of their use:

Both *tsakali* and thangkas have similar functions, but *tsakali* are used more when we do rituals, mostly initiations. So there are *tsakali* painted with the divinities, *tsakali* painted with lineage masters: individual lineage masters [depicted] one by one, [or] sometimes a group of lineage masters – it depends on how it is organised. As for their usage, [they are used] when we perform initiations. When we perform initiations or empowerment rites for a deity, there are different parts. Empowerment of the mandala uses such things as the vase, [while] empowerment of divinities uses the *tsakali* painted with the deities. Empowerment with the lineage masters [entails] showing each *tsakali*. Then there’s a prayer, a verse, and then normally practitioners have to imagine their particular lineage, whichever lineage is showing; and then, from his body speech, mind, crown, throat and heart, [there emanates] blue or white light (points at crown), red light (points at throat) or blue light (points at heart), representing all as the essence of the enlightened [ones], blessings, and the empowerment of the enlightened body, speech and mind of the particular master or divinity. So the lama who

gives the transmission also has to feel and imagine ... in a similar way, giving the blessings through this support of these *tsakali*, and the receivers have to imagine that. That is why we use *tsakali* as a support. The lama shows [the card], and then what is written on the back of the *tsakali* is basically some kind of phrase reflecting the certain enlightened qualities that master or divinity is endowed with. And then, the practitioner who receives the initiation, connecting and reflecting on these qualities, should try to fill the connection with certain notions and then receive blessings. That is what we have to do.²¹

3 The set of sixty-five *tsakali*: Physical description

The collection of illuminated cards that is the focus of this study contains sixty-five *tsakali* initiation cards belonging to the Dzogchen Zhangzhung Nyengyü system of the Bon religion. Each card is 9.4 cm in width by 20.2 cm in height. The cards were produced from one or sometimes more laminated sheets of paper of uniform size. In the latter case, one sheet was pasted to another by coating the page with an adhesive. A photograph of some of the items in the collection is shown in Fig. 3. According to numbers visible on the upper margins of the recto sides of the cards, there are two groups: Bundle 1, containing cards numbered from 0 to 57 (with nos 10 and 41 missing), and Bundle 2, containing eight cards designated by the letters A, B, C, D, E, F, G and H. The whole set of *tsakali* is described in the appendix.



Fig. 3: Illuminated cards called *tsakali* belonging to the Zhangzhung Nyengyü belief system.

²¹ The interview with Khenchen Tenpa Yungdrung Rinpoche was conducted via Skype by Agnieszka Helman-Ważny and Charles Ramble on 16 July 2023.

4 The inscriptions on the *tsakali*

Unlike earlier forms of the religion, Tantric Buddhism is an esoteric tradition in which advanced meditation techniques may be practised effectively and safely only by those who have been initiated by a qualified master. This is a principle that it shares with Bon, and it applies not only to the practice of tantra, but also to the system that is considered to be the apex of all spiritual endeavour, the Great Perfection, Dzogchen (rDzogs chen). These empowerments are passed down through a lineage from master to disciple, either in person or through visions, and any spiritual tradition for which an unbroken line of transmission cannot be demonstrated is regarded as inauthentic or invalid. Certain metaphysical techniques are said to have been discontinued precisely because the relevant authority died before being able to transmit it to a successor. This is the case, for example, of the Tantric technique known as *phowa drongjuk* ('pho ba 'grong 'jug), the ability to project one's consciousness into another body, whether human or animal, and thenceforth to occupy it as if it were one's own. That lineage – or, at least, the Buddhist version of it, as the Bonpo strand is said to remain unbroken – is considered to have come to an end when the last adept, who had entered the body of a bird, was killed by a rival. Disciples who are initiated into a spiritual practice are therefore inheriting the powers not only of their master, but of *all* the previous masters in the transmission line, which often – as is the case of the tradition with which we are concerned here – begins in a superhuman realm.

As part of the initiation process, the disciple sits in front of the master, at a somewhat lower level, and is shown each of the cards in turn while the master reads out the inscription on the verso side. The inscriptions on the set of *tsakali* that are the subject of this book are written in headless, *ume* (*dbu med*) script, and range in length from seven to ten lines, most of them being eight or nine lines long.²² The pattern is the same in each case:

²² The appendix provides Romanised transliterations and translations of all the *tsakali*. The text contains numerous contracted forms (*bskungs yig*) that are presented first in a form approximating the contraction, then expanded in parentheses, with no emendations of heterodox orthography. The text has not been edited, and only in a few cases have improved readings been suggested (in brackets, preceded by the sign <) to clarify the meaning or to justify the translation. The numbering of the *tsakali* follows the sequence applied by Yongdzin Tenzin Namdak. Each number is succeeded by the letter the *tsakali* bears on its recto side and the numerical equivalent of that letter immediately afterwards in parentheses. The fourth element is the caption under the figure on the recto side. Where the caption differs from the usual form of the name or contains extraneous material (in some captions the name is prefaced by *sras* or *de sras*, signifying '[spiritual] son

1. An opening exclamatory expression *e ma ho* – ‘how wonderful!’
2. Praise to the master represented on the recto, with a short statement of the significant quality or achievement attributed to him.
3. A sentence declaring that the master, who is like a spiritual essence, is bestowing an empowerment on the disciple, who is compared to an empty vessel waiting to be filled.
4. An aspiration that the disciple be empowered with the qualities or achievements of the master on the card being shown (no. 2 above).
5. A concluding threefold mantra: *A phad / ōṃ phad / hūṃ phad /*

Nos 1, 3 and 5 are unvarying, while nos 2 and 4 change according to the master in each case (see the card images in the appendix). The inscriptions on the cards that do not feature lineage masters are more varied, but all begin with the same exclamatory expression, and contain the aspiration that the disciple be empowered with the qualities represented by the image.

The cards are numbered according to two systems. At the top of the verso of each card is an Arabic numeral written in blue pen. These numbers were added by Yongdzin Tenzin Namdak, the senior teacher of the Bonpo community in exile, in 1986, when he first received the cards and was setting them in the proper order. The top of the recto side in each case bears a letter, following the convention used for identifying the volumes of multi-volume scriptural works. These letters were added by the painter, who would have written them at the same time as the captions for each figure, found directly under the image in the same red ink.

The first *tsakali* depicts a vase, *bumpa* (*bum pa*), which conventionally stands for a mandala, and hence the universe. Whether it bore a letter at the top is unknown due to damage – only the lower part has survived. In any event, the sequence of lineage holders begins with the second card, no. 1, which shows the Primordial Buddha. The first nine figures are all divine beings, and we would expect them to be marked from *ka* (the first letter of the Tibetan alphabet) to *ta* (the ninth letter). Although they have been numbered sequentially on the verso from 1 to 9, the sequence of letters on the recto actually runs as follows: *ka*, *kha*, *nga*, {*ca*}, *na*, *ca*, *pa*, *pha* and *ba*, corresponding to the numbers 1, 2, 4, {5}, 12, 5, 13, 14 and 15. The fourth and sixth *tsakali* both have the letter *ca*, but the double brackets around the first set (represented here by braces) suggest that it may belong to a different part of the collection; the letters of the fifth to ninth *tsakali* may perhaps be similarly explained.

[of the figure on the preceding card]’, or followed by *la*, ‘[transmitted] to’), the more usual form of the name is also given in parentheses.

The collection examined in this volume contains eight *tsakali* that (apart from the vase mentioned above) do not depict members of the Zhangzhung Nyengyü transmission. They have accordingly not been numbered on the verso by Yongdzin Tenzin Namdak, but they do have ordinal letters on the recto side. However, since some of these letters are shared by other *tsakali* in the collection, they are identified here by the (arbitrarily allocated) Roman letters A to H. The figures on these *tsakali* may be described briefly here.

{NGA} (4) The Cosmic Buddhas of the Five Families

Bottom: gSal ba rang byung, east, head of the Swastika Family
 Left: dGa' ba don grub, south, head of the Jewel Family
 Top: Bye brag dngos med, west, head of the Lotus Family
 Right: dGe lha gar phyug, north, head of the Wheel Family
 Centre: Kun snang khyab pa, centre, head of the Mind Family

The five *tsakali* B to F depict five of a group of divinities called the six subduing *shen* ('dul ba'i gshen drug). As mentioned in Chapter 2, each of these is responsible for the potential liberation of the beings inhabiting the six samsaric realms. During the phase of supplementary preliminary practice known as the 'inner distinction' (*nang gi ru shan*), disciples visualise themselves as each of these divinities in turn, with the aspiration to liberate the inhabitants of their respective realms. The *tsakali* contain certain anomalies. Conventionally, the Shen and their realms are the following:

Gods: Ye gshen gtsug phud
 Titans: lCe rgyal bar ti
 Humans: gSang ba 'dus pa
 Animals: Ti sangs rang zhi
 Hungry ghosts: Mu cho ldem drug
 Hell-beings: gSang ba ngang ring

Ye gshen gtsug phud is missing from the collection. In *tsakali* D (TA), gSang ba ngang ring, who should be responsible for hell-beings, has been allocated to the animal realm, while the usual master of the latter, Ti sang rang bzhin, has been put in charge of the hells. *Tsakali* B (NYA) depicts gSang ba 'dus pa, who is responsible for humans, but on the verso he is named as gSang ba ngang ring, which we assume to be a simple scribal error.

The last two *tsakali*, G ('I) and H ({ZA}), represent masters who do not appear to have any connection with the Zhangzhung Nyengyü, and have probably been included in this collection by accident. The verso of the former is blank, while the

text on the verso of the latter is written in a different hand from that of the scribe of all the other *tsakali*.

5 Paper

Within Bundle 1, when looking at the backlit paper of these *tsakali*, woven and laid papers could be identified. Card no. 23, depicting [De sras] gYung 'phan; card no. 25, depicting [De sras] dGe 'phan; and card no. D, depicting gSang ba ngang ring, were produced on a type of laid paper (Type 1). The remaining fifty-five (out of fifty-seven) cards are on a type of woven paper, however of two different qualities. Type 2a, a woven paper without any fibre bundles of 'cloudy' fibre distribution, was observed on *tsakali* nos 1–5, 7, 9, 11, 13, 15, 17, 19, 21, 34 and 56, and a slightly rougher Type 2b, a woven paper with many fibre bundles, was observed on *tsakali* nos 6, 8, 12, 14, 16, 18, 20, 22, 24, 26, 27, 28–33, 35–40, 42–55, 57–58. In Bundle 2, one *tsakali* contained the laid paper of Type 1, three cards contained the woven paper without fibre bundles of Type 2a, and four cards contained the woven paper with many fibre bundles of Type 2b. A summary of the results is presented in the appendix at the end of the book.

Charles Ramble

Chapter 2: The Teachings of the Dzogchen Zhangzhung Nyengyü System and Their Transmission

Abstract: The collection of *tsakalis* that are the subject of this volume are related to a system of Tibetan meditation known as the Dzogchen Zhangzhung Nyengyü, the ‘Oral Transmission of the Great Perfection from Zhangzhung’. In the Bon religion, as in certain branches of Tibetan Buddhism, the ‘Great Perfection’ (Dzogchen) is regarded as the supreme class of teachings and meditation. There are three systems of Dzogchen in the Bon religion: Atri, Dzogchen (used here in a specific sense) and Zhangzhung Nyengyü. The first two are classed as ‘treasure’ texts or *terma* (*gter ma*), believed to have been composed and buried many centuries ago in an era when Bon was under threat, and revealed at a more propitious time. The Zhangzhung Nyengyü, by contrast, is not a rediscovered treasure but an unbroken master-to-disciple oral transmission that is believed to have originated as a teaching bestowed by the Supreme Buddha named the ‘Ever-Excellent One’, Küntu Zangpo, and transmitted down generations of earthly masters to the present day. It is principally this lineage whose members are depicted on the cards. Following a presentation of the main principles of the Zhangzhung Nyengyü system of Dzogchen, this chapter will offer brief accounts of the members of the lineage who are depicted in the *tsakalis*, based on the biographical section of the cycle.

1 Introduction

The collection of *tsakali* considered here represents the transmission lineage of the teachings of an esoteric system known as Dzogchen, the ‘Great Perfection’, which is found in both Bon and certain schools of Buddhism. Bonpos believe that all the doctrines contained in their religion, generally referred to as Yungdrung (‘Eternal’) Bon to distinguish it from other, more marginal Tibetan religious beliefs and practices, were taught by their founder, a quasi-mythical figure known as Shenrab Miwo, who is considered to have lived many thousands of years before the historical Buddha Shakyamuni. Of the different schemes that Bonpos use for the classification of Shenrab’s teachings, the best known is a nine-tiered categorisation of ‘vehicles’ or ‘ways’, known as the ‘Nine Ways of Bon’. The ways are subdivided into three sets: four so-called ‘lower’ or ‘causal’ vehicles, consisting of

rituals that are probably largely of indigenous Tibetan origin; four ‘higher’ vehicles, or ‘ways of result’, containing teachings that are significantly cognate with, if not demonstrably derived from, Buddhist concepts; and finally, a single vehicle known as the ‘supreme way’, which consists entirely of teachings related to the Great Perfection.

Bon has three different traditions of Great Perfection teachings. These are, first, the Dzogchen Yangtse Longchen (Yang rtse klong chen), which is more commonly referred to simply as Dzogchen; secondly, Atri (A khrid), ‘Instructions according to the Letter A’; and finally, the Dzogchen Zhangzhung Nyengyü, the ‘Aural Transmission from Zhangzhung’. The first is believed to have originated from a threefold set of teachings that were given by a celestial incarnation of Shenrab Miwo named Chime Tsukphü (‘Chi med gtsug phud). These foundational teachings, known as the Three Proclamations, derive their name from the belief that Chime Tsukphü promulgated them among the gods, serpent spirits and humans. According to the transmission narrative, the teachings were brought to Zhangzhung – a land situated in the west of Tibetan and parts of Central Asia and regarded as a sacred land by Bonpos – by a saint named Nyachen Lishu Taring (sNya chen Li shu stag ring), who then went on to introduce them to Tibet proper. This coincided with the period when Buddhism was being established as the official religion of Tibet, and the emperor at the time, a convert to the new religion, was persecuting Bon. To save his teachings from destruction, Lishu Tagring concealed them with the intention that they be rediscovered at a more propitious time for Bon. The rediscovery occurred in the eleventh century, when they were revealed by a certain Zhötön Ngödrub Dragpa (gZhod ston dNgos grub grags pa) – considered to be Lishu Tagring’s reincarnation – from their place of concealment in southern Tibet.

Unlike the Dzogchen line, the Atri tradition makes no claim to having originated in an ancient era or a sacred land, but was a scholarly composition from the eleventh century, and is therefore contemporary with the Dzogchen cycle that is classified as a ‘revealed treasure’ (*terma*). The author of the Atri was a remarkable figure called Gongdzö Ritröpa (dGongs mdzod ri khrod pa, 1038–1096) of the Meu (rMe’u) lineage, one of the six main Bonpo families in central Tibet. The original form of the teaching was organised into eighty practice sessions, but in the thirteenth century a certain Gyalwa Yungdrung of the Dru family (Bru rGyal ba g.yung drung, 1242–1290), a disciple of Gongdzö Ritröpa’s main spiritual heir, restructured it into fifteen sessions. The Atri came to be closely associated with the Dru family and was especially practised in Menri (sMan ri), the main monastic seat of the Bonpos in central Tibet that would be founded by a member of the Dru family in the fifteenth century.

The third of the Bonpo Dzogchen traditions, the Zhangzhung Nyengyü, is – as its name indicates – regarded as an unbroken master-to-disciple transmission. In this respect it differs from the Dzogchen Yangtse Longchen, which is classified as a ‘treasure’ cycle (*terma*) since it is believed to have been brought to light after three centuries of concealment. The system is considered originally to have been conceived and taught by the Buddha Küntu Zangpo (Kun tu bzang po), the ‘Ever-Excellent One’, who corresponds to the figure of Samantabhadra of the Buddhist tradition. Through a process of mind-transmission it passed to another set of enlightened beings known as the ‘nine blessed ones’, and from there to another series, the ‘twenty-four saintly masters’, in the land of Zhangzhung. Gyerpung Nangzher Löpo (Gyer spungs sNang gzher lod po), an eighth-century figure, is credited with subsequently committing it to writing in the Zhangzhung language.

The philosophical system known as the Great Perfection has a long and intricate history that is still the subject of extensive discussion among scholars, and its underlying concepts are complex and often elusive. While this is certainly not the place to undertake a detailed exposition of the system and its tenets, in view of the fact that the figures depicted on the cards that formed the subject of this book represent the transmission of its most important development in the Bon religion, the first part of this chapter will present a general introduction to central premises and the procedures that are followed in order to achieve its goals. The second part will set out the main stages in the transmission of the Zhangzhung Nyengyü down to the last lineage-holder represented in our collection of *tsakali*.

Recent years have seen a dramatic increase in the number of works related to Dzogchen intended both for the scholarly community and also for Western followers of Buddhism and Bon. Since the purpose of this chapter is not to engage in the complexities of Dzogchen philosophy or the details of its historical developments, but to provide a general outline of the system that was perpetuated by the lineage depicted on the *tsakali*, this overview will be based on a limited number of studies that deal with the system’s main features, especially those relating to the Zhangzhung Nyengyü, and on works concerned with the hagiographies of the masters. The outline of the doctrine given here is based mainly on the relevant sections of the studies by Samten G. Karmay, Donatella Rossi, John Myrdhin Reynolds, Jean-Luc Achard and Loel Guinness,¹ while the structure of the lineage itself is indebted to Karmay, Reynolds, Henk Blezer and Yongdzin Lopön Tenzin Namdak.² For the intricacies of the interconnections between the different

1 Karmay 2007; Rossi 1999; Reynolds 2005; Achard 2008; Guinness 2021.

2 Karmay 1998; Reynolds 2005; Blezer 2009–2010; Yongdzin 2010.

branches of the transmission the reader is referred to the chart in Blezer's article and especially to the lineage tree diagram in Yongdzin's 2010 volume.³

2 The basic concepts of Dzogchen

One of the fundamental ideas in the teachings of the Great Perfection is the 'base' (*gzhi*), of which the natural state, *neluk* (*gnas lugs*), is essentially pure (*kadak, ka dag*). The base is also expressed as the primordial base, *döme zhi* (*gdod ma'i gzhi*), or the base of all, *künzhi* (*kun gzhi*). The identity between the primordial base and the base of all is disputed by certain Tibetan commentators because the latter term is also used in a different way in the context of certain Mahāyāna schools in relation to the 'storehouse consciousness' (Tib. *kun gzhi rnam shes*, Sk. *ālaya-vijñāna*). The primordial base is personified in the Great Perfection as the primordial Buddha Küntu Zangpo (Tib. Kun tu bzang po), who is represented on the first *tsakali* in the series – no. 1 – to feature an anthropomorphic figure.

The system accords great importance to the mind. The natural state, the primordial base, is understood not as the actual mind, *sem* (*sems*) but as the *nature* of the mind, *semnyi* (*sems nyid*). A fundamental feature of the human condition is that the mind is disengaged from its own nature, and the moment at which this slippage occurs is understood as nothing less than the inception of *samsāra* ('cyclic existence'). The moment of disjunction is evocatively expressed in a text entitled *The Vast Expanse of the View* (*lTa ba klong yangs*).⁴ The work is classed as a treasure text, *terma* (Tib. *gter ma*) that was discovered by Dorje Lingpa (rDo rje gling pa, 1346–1405). Although it is considered to be a Buddhist treatise on the Great Perfection, it may be noted that Dorje Lingpa also discovered several important works belonging to the Bon religion, and is accordingly sometimes known by the Bonpo name of Yungdrung Lingpa (gYung drung gling pa).

The immovable moved slightly,
The unquivering quivered slightly,
Although there is no motion of the Basis,
The motion comes out of the versatility of the Intellect.
The versatility is called the Mind.
It is also that of spontaneous compassion.
Just like the wind of the breath of a small bird.

3 Blezer 2009–2010, 74–77; Yongdzin Lopön Tenzin Namdak 2010, 36. For an extensive list of primary sources relating to the Zhangzhung Nyengyü, see Blezer 2011.

4 Karmay 2007, 228.

Or the movement of the unborn cock.
 Or one hundredth part of the hair from a horse's tail split into a hundred.
 Such is the quivering which joins intellect to mind.
 This is called the Innate Nescience.⁵

The purpose of spiritual practice in the Great Perfection is for the mind to recover its lost identity with its own nature, a reunion that is referred to as ‘the child being reunited with its mother’.⁶ While this disengagement is characterised by ignorance, *marikpa* (*ma rig pa*), the reunion of the mind and its nature is synonymous with awareness, *rikpa* (*rig pa*). The primordial base may be ineffable, but it is said to be characterised by three features: emptiness, clarity and energy.

2.1 Ground, Path and Fruit

The concept of the ‘ground’ or ‘base’, *zhi* (*gzhi*) is the point of departure for a process of self-liberation that Dzogchen texts present as having three stages of which the second and third are, respectively, the ‘path’ and the ‘fruit’. Tantric practice in both Buddhism and Bon requires neophytes to undergo a period of preliminary practice – which may in certain cases last for several years – both in order to ensure the efficacy of the techniques that are to be applied during the main engagement and also to protect them from harm that may rise from the potentially dangerous transformations that follow. In this respect, the Great Perfection is no different. In the case of the Zhangzhung Nyengyü, the preliminary practice followed is based on a set of procedures formulated by a pivotal figure in the transmission of the system, Dru Gyalwa Yungdrung (Bru rGyal ba g.yung drung, 1242–1290), who was also responsible for systematising another of the main Bon Dzogchen systems, the Atri. The text in question, entitled *rGyal ba phyag khrid* (‘[Dru] Gyalwa [Yungdrung]’s Manual of Instruction’), stipulates nine practices, organised into three sets of three.

- a. Practices that are valuable in general (*spyir gces pa'i sngon 'gro gsum gyis 'dul ba*)
 1. *Initiation*. Like tantra, the Great Perfection is an esoteric system in which the figure of the master is all important. Without the conferral of empowerment by a qualified teacher it is considered that any attempt at following the subsequent procedures would be pointless.
 2. *Meditation on impermanence*. In Bon and Buddhism alike, the fundamental impediment to any kind of spiritual progress is an individual’s at-

⁵ Karmay 2007, 189.

⁶ Karmay 2007, 176.

tachment to *samsāra* ('cyclic existence'), and the purpose of this particular practice is to generate awareness of the evanescence of worldly life. This second practice is subdivided into nine sections, each representing a different aspect of samsaric impermanence (life, material possessions and so forth).

3. *Confession of sins.* The act of admitting to and confronting one's misdeeds is seen as an unburdening of oneself and hence an essential step in the process of detachment.
- b. Purifying the mental continuum by means of the three preliminary practices that are in harmony with everything (*kun dang mthun pa'i sngon 'gro gsum gyis rgyud shyong ba*).
 4. *Generating the thought of enlightenment.* This is a commitment to the principle that whatever spiritual practice one undertakes is intended primarily for the benefit of others, not oneself.
 5. *Taking refuge.* As is well known, in early forms of Buddhism the place of refuge is the Triple Gem – the Buddha, the Dharma, and the monastic community. The Great Perfection shares with tantric Buddhism the difference that the principal refuge is one's own master, who is superior even to the Buddha. In the Zhangzhung Nyengyü, the meditator visualises the master as Künzang Shenlha (Kun bzang gshen lha), a manifestation of the divinity Shenlha Ökar (gShen lha 'od dkar). While Künzang Shenlha – one's own master – may be the focus of this exercise, he should be visualised as being surrounded by all the other classes of divinities – meditational deities, *dakinis* and so forth – as well as all the lineage masters, notably those that feature in this collection of cards that make up the divine assembly of the Zhangzhung Nyengyü.
 6. *Mandala offering.* This procedure, which signifies the offering of both oneself and the universe to the divinities and saints in the assembly invoked in the preceding practice, is generally enacted symbolically: the disciple repeatedly creates and dismantles a model of the universe consisting of a set of three vertically arranged metal discs that are filled with grain, emptied out, wiped clean, and again reassembled. Ideally, the sequence should be performed 100,000 times.
- c. Purifying the mental continuum through three especially exalted preliminary practices (*khyad par 'phags pa'i sngon 'gro gsum gyis rgyud dag par bya ba*).

7. *Mantra recitation.* This entails the repetition of a set of prescribed sacred formula – as in the previous case, ideally 100,000 times – while performing the appropriate visualisations.
8. *Offering one's body.* The procedure that constitutes this component is in fact a ritual that is often performed as a 'stand-alone' meditation, and almost has the status of a subsidiary school of Tibetan Buddhism. Literally translated as 'cutting-off', the practice is classically undertaken in terrifying settings, strewn with human remains, such as battlefields or, most commonly, charnel grounds, where the sense of impermanence is particularly acute. Using instruments made of human body parts (such as thighbone trumpets and skull drums) the practitioner invites 'guests' from the different realms of *samsāra* to dismember and consume his or her body. The dramatic visualisations are considered to be a physical manifestation of the true purpose, which is the cutting off of ego-clinging.
9. *Prayer for blessings.* In this final discipline, the practitioner prays to his or her own master and to all the lineage masters. More than just the passive reception of blessings, the procedure entails a visualisation whereby one is integrated with the lineage in such a way as to become a vessel suitable for the transmission of the masters' qualities.

The Zhangzhung Nyengyü system entails a second set of preliminary practices known as 'distinctions', *rushen* (*ru shan*). This set is divided into an outer, an inner and a secret stage. The first is intended to instil in the practitioner a profound aspiration to achieve detachment from *samsāra* by successive identification with the denizens of each of its realms (gods, titans, humans, animals, hungry ghosts and hell-beings), thereby effecting a separation between the samsaric and nirvanic realms.

In Buddhist depictions of the Wheel of Life, each of the six samsaric realms features an image of the bodhisattva Avalokiteśvara, who represents the possibility of liberation from that realm. In the Bonpo Wheel of Life, the same role is played by a set of divinities known as the 'six subduing *shen*', all considered to be manifestations of Shenrab Miwo, the Bon equivalent of Shakyamuni. In the second – the inner – *rushen*, practitioners undertake visualisations in which they identify with each of the subduing *shen* in succession in order to liberate the inhabitants of the respective realms under their tutelage. In the final phase of purification, the secret *rushen*, the practitioner develops concentration by focusing on an image of the Tibetan letter A. The practice, known as Atri, 'Instructions according to the Letter A', is also the name of the one of the other two systems of Great Perfection.

These preliminary exercises are often supplemented by yogic techniques that are not intrinsic to the Great Perfection but also feature in tantric training. The exercises fall under the general category known as ‘channels and winds’, *tsalung* (*rtsa rlung*), since they involve the activation of the anatomical components of a subtle body, requiring regulated breathing techniques in combination with appropriate visualisations. The exercises are believed to have noticeable physical manifestations, as in the practices known as *tummo* (*gtum mo*), the generation of bodily heat, and ‘essence-extraction’, *cülen* (*bcud len*) which enables the adept to live for protracted periods without conventional nutrition.

The preliminary practices and the three *rushen* are followed by two important steps that, although not unique to the Great Perfection, are very characteristic of it. In early sources – notably the thirteenth-century practice manual by Dru Gyalwa Yungdrung mentioned above – these are referred to as essential purity, *kadak* (*ka dag*) and *ösel* (*’od gsal*), ‘clear light’, but Bon later came to adopt the corresponding terms for these that were used in the Buddhist Dzogchen tradition, *threkchö* (*khregs chod*) and *thögal* (*thod rgal*). The former is variously translated as ‘cutting through’ or ‘cutting off rigidity’, and refers to the practitioner’s severance of bonds to samsaric habits and the ability to abide effortlessly in the awareness, *rikpa*, of the natural state. *Thögal*, which may be translated as open ‘leaping over’, is an advanced practice that can only be undertaken on a foundation of proficiency in the preceding stage, since it involves encountering visions which, without this secure base, would be nothing more than meaningless illusions. One of the three main procedures used in *thögal* is the dark retreat, where the practitioner remains in complete darkness for a period of forty-nine days. This duration is a reference to the length of time an individual is considered to spend in the intermediate state, the *bardo* (*bar do*) between death and the subsequent incarnation, and is explicitly regarded as being a preparation for this post-mortem condition, which itself offers a vantage point for liberation from cyclic existence. The dark retreat is the first of three steps, the other two being sky-gazing, in which the meditator faces the blue sky with open eyes, and sun-gazing, in which he or she stares not directly at the sun, but at a point below it, for extended periods.

The onset of visions marks the beginning of the last stage in the practice of the Great Completion. The visions take the form of lights of different shapes, sizes and colours that arise and develop in a sequence of recognised stages, and although they are considered to be manifestations of the primordial base, they are essentially symptomatic of the practitioner’s progress, and are themselves illusory. The later manifestations are an indication that the awareness is flowing through the subtle channels without impediment. At the conclusion of the sequence of transformations, the visions and accompanying sounds disappear altogether in the

stage called the ‘open vision of exhaustion in the ultimate state of existence’ (*bon nyid zad pa'i snang ba*), leaving only the awareness unencumbered emptiness that is the final achievement of the Great Perfection. This attainment may itself have certain physical manifestations, most notably the dissolution of the practitioner’s physical form into light, in a condition referred to as ‘rainbow body’.

3 The main content of the transmission

Before turning to the transmission lineage of the Zhangzhung Nyengyü, whose members are represented in the cards in the collection, a few words may be said about the content of what was transmitted. The legacy that has been passed down is classified in two different sets: the ‘transmission of experience’ (*nyams rgyud*) and the ‘transmission of the word’ (*bka' rgyud*). The former consists of precisely that – accounts by past masters of their personal experience following their application of the methods of the teachings. A more formal treatment of the system is given in the teachings that make up the transmission of the word. These comprise four sets of texts representing successive stages in the practice of the Great Completion, as follows:

1. The external teachings that are a general summary of the view (*phyi lta ba spyi gcod*), consisting of nine texts dealing with the general concepts and the basic practices that form the foundation of the Great Perfection.
2. The inner teachings that are the direct instructions (*nang man ngag dmar khrid*), a set of five works concerned primarily with the practice of meditation, with particular attention to the procedure called ‘cutting through’ (*threkchö*) described above.
3. The secret teachings for seeing [existence] in its nakedness (*gsang ba rig pa gcer mthong*). The five texts that make up this group guide the practitioner in the more advanced stages of meditation, and notably the techniques for undertaking the stage called ‘leaping over’ (*thögal*).
4. The ultra-secret teachings for attaining the final resolution that is the natural state (*yang gsang gnas lugs phug chod*); five texts that explain the method of attaining the fruit that is the ultimate achievement in the Great Perfection. The teachings contained in this quartet are believed to have been passed down orally until they were committed to writing by Yangtön Sherab Gyaltsen (Yang ston Shes rab rgyal mtshan, 1077–1141; no. 52), about whom more will be said below.

4 The lineages of the Zhangzhung Nyengyü

The divinities and masters depicted in the cards, the successive holders of the teachings of the Zhangzhung Nyengyü, are conventionally grouped into a number of subsidiary lineages, not all of which are represented in the set that is the subject of this volume. The main grouping consists of two sets, known respectively as the ‘long’ or ‘distant’ transmission (*ring rgyud*) and the ‘near’ or ‘recent’ transmission (*nye rgyud*).

This ‘long transmission’ is divided into several subsidiary sets. The first group is known as the ‘mind transmission of the blessed ones’ (*bder gshegs dgongs rgyud*) (nos 1–9). These nine figures are all transcendental beings of whom the first, Küntu Zangpo (Kun tu bzang po), is the personification of the natural state itself. The name of the group derives from the belief that the doctrines of the Zhangzhung Nyengyü were passed from each holder to the next by direct mind-to-mind transmission.

These nine are followed by a group called the ‘twenty-four men of the oral transmission’ (*gang zag nyi shu rtsa bzhi*). From the beginning of this stage, the teachings were communicated orally by a master to a single disciple, and the lineage is therefore referred to as a ‘single transmission’ (*chig rgyud*). It is said that, in order to ensure that there was no leakage, so to speak, the essential teachings were spoken directly into the disciple’s ear by the master through a bamboo tube.

The twenty-four masters in this part of the lineage are further subdivided into four groups:

1. Five transcendent lamas (*la zla ba’i bla ma lnga*), nos 11–14 (no. 10 is missing).
2. The sixfold awareness transmission of the knowledge-holders (*rig ’dzin rig pa’i rgyud pa drug*), nos 15–20.
3. The ninefold transmission through the ears of men (*gang zag snyan rgyud kyi rgyud pa dgu*), nos 21–29.
4. The fourfold transmission of the scholar-translators (*mkhas pa lo paṅ gyi rgyud pa bzhi*), nos 30–33.

In contrast to this unbroken succession of master-to-disciple transfers, known as the ‘uninterrupted transmission’, there are further branches known as the ‘three interrupted lineages’. The interruptions in this case refer to a number of lacunae in which the transmission was received in a vision from a master of an earlier age:

1. The seventeen who were descended from Chime Tsukphü (no. 8), who was born from warmth (*drod skyes ’chi med gtsug phud nas brgyud pa cu bdun*).
2. The nine who were descended from Sangwa Düpa (no. 9), who was magically born (*rdzus skyes gsang ba ’dus pa nas brgyud pa dgu*).

3. The eight who were descended from Yeshe Tsukphü, who was born from an egg (*sgong skyes ye gshen gtsug phud nas brgyud pa brgyad*). Yeshe Tsukphü, who is believed to have received the teachings directly from Küntu Zangpo, is not represented in the collection.

All these lineages culminate in the person of Nangzher Löpo (sNang bzher lod po, no. 35), to whom we shall come presently, but, since none of their other members feature in our collection of *tsakali*, we need not give them any further consideration here. The ‘long transmission’, which comes to an end with Dawa Gyaltzen (Zla ba rgyal mtshan, no. 33), is followed by the ‘near transmission’, initiated by two particularly important figures: Tapi Hritsa (Ta pi hri tsa, no. 34) and his disciple, Gyerpung Nangzher Löpo (Gyer spungs sNang bzher lod po, no. 35), who form a pair known as the ‘two dear emanations of the close transmission’ (*nye brgyud kyi sprul sku drin can gnyis*). Until this point the Zhangzhung Nyengyü had been first a mind-to-mind and subsequently an oral transmission, but the particular significance of Tapi Hritsa is that he authorised his disciple Nangzher Löpo to commit it to writing in the language of Zhangzhung.

From Nangzher Löpo the teaching passed to a succession of six masters known as the six meditators of Zhangzhung Mar (*zhang zhung smar gyi grub chen drug*). The last of these six, Pönchen Tsenpo (dPon chen btsan po), is another important node in the transmission since he is the gateway through which the teachings crossed from Zhangzhung into Tibet after he translated them into the Tibetan language. The fact that the *tsakali* representing him is one of the few that is missing from the collection may be a reflection of his pivotal position: we do not know why the card is missing, but we may speculate that it was due to its particular importance – for example, with a view to being placed on a domestic shrine or borrowed to be used as the model for a copy and never returned.

After Pönchen Tsenpo, the lineage bifurcated into one branch called the ‘five lamas of the lower transmission’, through whom only the ‘transmission of experience’ (*nyams rgyud*) was passed down, and another, the ‘six lamas of the lower transmission’ who perpetuated the ‘transmission of the word’ (*bka’ rgyud*) that is, the four main doctrinal cycles. The two branches were reunited in another watershed figure, Yangal Sherab Gyaltzen (1077–1141, no. 52), often known by his title Yangtön Chenpo (Yang ston chen po), ‘the great teacher from the Ya ngal clan’, about whom there is still a rich oral tradition in the Nepalese district of Mustang, which he visited in his youth, and in Dolpo, where the Yangal clan continues to flourish. If Yangtön Chenpo is revered in the tradition of Bon followers as the point of convergence of the upper and lower transmissions, he is also accorded a

position of special importance in Western scholarship on the Zhangzhung Nyengyü for nothing less than being ‘probably [...] the only historical figure in [the] exalted company of saints and scholars in the lineage up to this point’.⁷ Henk Blezer further underlines the probable importance of Yangtön Chenpo in committing the tradition to writing:

He is a figure of paramount importance for the codification of the Zhang zhung snyan rgyud and its narrative. He and his teacher, ‘Or sgom kun ‘dul, were the first to write things down from the *Nyams rgyud*, by way of mnemonic notes, on Yang ston chen po’s request [...]. In spite of the copious narratives on the legendary sNang bzher lod po, this may in fact be the first time that anything has been preserved in writing.⁸

Both the upper and lower transmissions are represented in our *tsakali*, with six members of the former (nos 42–47) preceding the five who constitute the latter (nos 48–52) before converging in the figure of Yangtön Chenpo (no. 52). Lomting Lhagom Karpo, who should figure between Shengyal Lhatse (no. 49) and Ngödrup Gyaltsen Ringmo (no. 50), is missing from the collection. The numbering on the verso is continuous (from 49 to 50), but on the recto the alphabetical ordering passes directly from *ri* to *shi*, signifying that the intervening *li* is absent.

The northern branch – which is in fact generally less well known – is not represented at all in the *tsakali*, and the collection ends partway through the southern branch. The penultimate individual to be depicted is Cikchö Depa Sherab (no. 57), the fifth in this group of eleven. He is followed by Lama Rangdröl Gyaltsen, the last figure in the collection. The number given on the verso of the former is 57, while the final *tsakali* has no number. On the recto these two *tsakali* are marked respectively as *ngu* and *chu*, indicating that the card between them – which should be *cu* – is missing. However, Rangdröl Lama Gyaltsen is the eighth member of this group, meaning that two members, not one, are missing between him and Cikchö Depa Sherab. The masters in question are, respectively, Druchen Gyalwa Yungdrung (Bru chen rGyal ba g.yung drung) and Latö Riwa Sherab Lodrö (La stod Ri ba Shes rab blo gros) – the sixth and seventh members of this group – and unfortunately we have no way of knowing which of these was intentionally omitted by the creator of this set of cards. Druchen Gyalwa Yungdrung is an especially important figure in the domain of Bonpo Dzogchen. In addition to being the author of one of the main practice manuals for the Zhangzhung Nyengyü, he was also a key figure in the reorganisation and transmission of another of the main

⁷ Blezer 2009–2010, 87.

⁸ Blezer 2009–2010, 87–88.

Dzogchen systems, the Atri. Since he does feature on a card in the Atri subset of this *tsakali* collection, he may have been omitted here on the grounds that the card could be inserted at the appropriate place in the Zhangzhung Nyengyü subset if it were ever needed there for an initiation.

The relationship between the different biographical accounts of the Zhangzhung Nyengyü masters has been carefully analysed by Henk Blezer.⁹ The most widely cited source, and the one that was used for the studies by Samten Karmay and John Reynolds, is entitled *rGyud pa'i bla ma'i rnam thar* ('The Biographies of the Lineage Lamas [of the Zhangzhung Nyengyü]'), which was composed in 1419. The author was Patön Tengyal Sengge Pal Zangpo (sPa ston bsTan rgyal seng ge dpal bzang po). Patön was the eleventh member of the southern transmission, and his account of the lives of the masters ends with his immediate predecessor, Kartsa Sonam Lodrö (Kar tsa bSod nams blo gros). He perpetuated both the southern and northern transmissions, and a later account by Kyangtrul Namkha Gyaltsen (sKyang sprul Nam mkha' rgyal mtshan) adds a further eight generations.

This raises the question: why does our collection of cards conclude three generations before the end of the first stage of the southern transmission? One obvious possibility is that any cards there may have followed featuring the successors of Rangdröl Lama Gyaltsen have been removed or lost. Another possibility is that the most recent members of the lineage were simply omitted by the painter or whoever commissioned the work – after all, the entire northern transmission descending from Yangtön Chenpo, most of whom would have been contemporaries of Rangdröl Lama Gyaltsen and his predecessors in the southern transmission, is absent. In support of this last argument is the fact that even though the set of cards illustrating Yongdzin Lopön Tenzin Namdak's exposition of the tradition is clearly a modern creation it ends with Lomting Lhagö Karpo (Lom ting lha sgom dkar po) of the transmission of experience, two generations *before* even Yangtön Chenpo, and omits the masters of the transmission of the word.

While both of these explanations are entirely plausible, it is worth considering another possible reason for the collection ending at this point. Henk Blezer refers to a collection of hagiographies of Zhangzhung Nyengyü masters that antedates that of Patön by three generations. This text, entitled *Bla ma'i rnam thar lo rgyus rnam rgyas pa* ('Extensive Biographical Accounts of the Lamas [of the Zhangzhung Nyengyü]'), was composed by Rangdröl Lama Gyaltsen, the last line-

9 Blezer 2009–2010, esp. 89–139.

age-holder to feature in our collection. Rather than constituting an incomplete representation of the lineage it may instead be a *complete* record of the masters who are known to have lived up to that time: while the art-historical analysis in the next chapter suggests that the collection was created around a century after this time, the presence of archaic features may be explained by the *tsakali* having been copied from an earlier set that was created during or soon after the lifetime of the last master to be depicted, and therefore early in the fifteenth century.

Christian Luczanits

Chapter 3: Art-historical Analysis of the *Tsakali* Collection

Abstract: At first glance, the set appears consistent and ancient. It largely is painted in a style most commonly associated with the fourteenth century; however, it is an archaising style, as elements found on some of the figures, such as the lower garment of the Buddha's dress, indicate a somewhat later date. This chapter will analyse the set from an art-historical perspective, considering the derivation of its style and the basis of its iconography compared with those of portable paintings and murals from across the Himalayas. Besides the actual date of the set and its different parts, its potential place of manufacture will also be assessed.

1 Introduction

There are various ways in which this group of *tsakali* can be looked at in art-historical terms. In the following, I begin with a formal analysis before accounting for elements of style and content. I restrict my formal analysis to composition, figure typology and colour, as measurements, physical properties and materiality are discussed in other chapters.

At first glance, the group of *tsakali* appears largely consistent. While only the damaged *tsakali* depicts an object, all the others have figures. Among the latter, only one features five figures, while all the others are dedicated to single figures. These are seated or standing on a prominent lotus seat and framed by both an outer, U-shaped frame and a combination of nimbus and cushion.¹

In other words, only two of the sixty-five *tsakali* diverge from a standard composition that shows a single figure. Of those with single figures, three share a pointed arch around the number above the painting, as we also find in the *tsakali* of five figures.² These four thus form a group that is separate from the main

1 I call the lower frame of the body a 'cushion' rather than a 'mandorla', as the seated figures still show the ornaments where nimbus and cushion meet. Thus, its derivation from a throne back is still recognisable.

2 Potentially three more paintings of this set have been published in Kvaerne 1995, pl. 45.1–2 and pl. 48. Regardless of whether these paintings belong to the same set, they were produced at the same workshop as the paintings discussed here.

group. Of the main group, sixty of originally at least sixty-six *tsakali* are extant. In my analyses below, I first consider the main group, and then compare the resulting observations to those of the second group, before speculating to which set the only object may have belonged to.

All the *tsakali* have a central vertical panel framed by a broad yellow border with proportions approximating two in height to one in width (2:1). This is ideal for the standing figures, but the picture field was actually composed for seated figures, with the lower quarter of the panel occupied by the lotus seat and a patch of sky studded with blossoms underneath. The outer U-shaped frame for the figure covers most of the upper three quarters, leaving only small, almost triangular patches of sky in the upper corners. These three areas of sky are demarcated by thick black outlines that appear to push the figured area towards the viewer. The usage of this technique can occasionally be observed in early Tibetan painting ranging from around 1200 to at least the fifteenth century.³

Together, the three areas of sky are also of broader symbolic significance, as they make the figures of the *tsakali* hover in the sky. In the case of the first figure in the set, Samantabhadra, this uniformity is broken insofar as the lotus has double petals and a stem that traverses the lower sky area, signifying that this stem symbolically holds the entire set. Closer observation of this painting also reveals that here the lotus seat is higher than usual, a detail to which we return below.

If we divide the figured area into the other three quarters and subdivide each of these quarters into thirds, the overall compositional principle becomes apparent (Fig. 1). The quarter lines are at the height of the eyes and the centre of the figure's body, while the thirds of these quarters converge with major compositional areas of the figure. In the uppermost quarter, the thirds meet the bottom and top of the crown; in the middle quarter, they are at the heart and neck; and in the lower quarter, they are at the edge of the dhoti and just at the lower point where the two legs cross. In other words, if we divide the entire height of the panel into twelve parts, the dividing lines define all the main areas of the composition. The same divisions have been used for the standing figures, which results in a disproportionally large head on a rather slim body.

³ This technique occasionally occurs in the Alchi Group of Monuments, most pronouncedly in the Four Image Chörten of Mangyu (see, e.g., Linrothe 1994). Significant later examples are found in Shalu, Gyantse and Jonang (see, e.g., Tucci 1949, figs 31–38, 49, 53, 54). Portable paintings also occasionally use such outlines (see, e.g., the Raktayamāri mandala made for Jangpukpa Künga Lekpa (active in the first half of the fifteenth century) at the Metropolitan Museum of Art (<<https://www.metmuseum.org/art/collection/search/78193>>, accessed on 21 July 2025)).



Fig. 1: Seated deity (Tsakali 8, no. *pha* (14)), standing deity (Tsakali B, no. *nya* (8)) and monastic (Tsakali 35, no. *di* (41)) of the main set with compositional lines added.

While this compositional principle can be observed throughout the set and explain its uniformity, there is considerable variation in its application. Lines are rarely completely straight, and the postures of the figures are varied, as are the colour combinations.

2 Typology of figures

If we now move to the typology of figures⁴ on the basis of the main set, we have primordial Buddha types represented naked and performing meditation. One of these types, found at the beginning of the set, is blue (Tsakali 1, no. *ka* (1); *ye nyid kyis ston pa* = Samantabhadra), while the other, identified as Tapihritsa (Ta pi hri tsa; Tsakali 34, no. *thi* (40)), is white (Fig. 2). Then there are deity types, bejewelled and wearing scarves around their shoulders, one of them being female (Tsakali 7;

⁴ In the absence of detailed knowledge of Bon terminology, I must resort to the terminology I use for Buddhist art. Given how close the two religious traditions are, these should still be largely comparable.

no. *pa* (13)). The standing figures, five of the original six teachers of the discipline associated with the realms of rebirth, are bejewelled and wear long dhotis,⁵ but no scarves. They are depicted in succession between the deity types, which conclude with a white snake deity (Tsakali 11, no. *tsa* (17)) that represents a type of its own (Fig. 2).



Fig. 2: Primordial Buddha (Tsakali 34, no. *thi* (40)), snake deity (Tsakali 11, no. *tsa* (17)) and siddha (Tsakali 14, no. *wa* (20)) types of the main set.

By far, the largest group are those of the siddha type (twenty-seven cards of the main set; right part of Fig. 2 and Fig. 7). The figures of this type are commonly naked except for a dhoti around the hips, and are seated in a variety of relaxed postures. Most of them have hair with thick curls; some have beards; and only two wear additional garments. They thus resemble practitioners in Zhangzhung, while those in Tibet are dressed either as lay practitioners or monks. Of the former, some have curled hair, while others have their hair bound in a topknot.⁶ Further, a group generally represented later in the lineage wears distinct pointed hats with

⁵ A garment worn by male Hindus, consisting of a piece of material tied around the waist and extending to cover most of the legs.

⁶ A knot of hair arranged on the top of the head.

the sides turned upwards, recalling the hat of Padmasambhava (Fig. 3). Finally, three paintings show monastics, who can be recognised by the sleeveless vests they wear underneath their robes.



Fig. 3: Hatted lay practitioner (Tsakali 42, no. *tshi* (48)), lay practitioner with topknot (Tsakali 45, no. *zhi* (51)) and monastic (Tsakali 53, no. *i* (60)) of the main set.

The fragmentary second set, with pointed arches framing the painting numbers, is very similar in style to the main set and likely from the same workshop, but it also bears distinctive elements (Fig. 4). Not only do we have another type here, a Buddha in monastic robes (Tsakali 4, no. {*ca*} (4); identified as *tshad med 'od ldan*), but the hats of the lay practitioners are also distinctive. These are round on top, with an arched rim and long earflaps not seen in the other group. Further, the robes of the teachers and one of the hats are patterned in gold. Clearly there is an attempt to distinguish this group.

3 Colour palette, iconographic significance and style of painting

In the colour scheme used, red predominates, as it forms the background of the figured area through the U-shaped outer frame, but is also often used for parts of the dress and some lotus petals. It is likely that only the skin colour of the deities is based on descriptions and holds iconographic significance. Among the siddha types, lighter or darker tones of skin prevail, but there are also green, red, blue and yellow siddhas. These colours do not occur among the Tibetan representatives. For all other elements of the paintings, it is unlikely that specific colours were prescribed from the outset. Instead, we have to take the variations in the colouring of the nimbuses, halos, dresses and lotus petals as aesthetic choices.



Fig. 4: The five esoteric Buddhas (Tsakali A, no. {nga} (4)), Buddha in monastic robes (Tsakali 4, no. {ca} (5)) and lay practitioner with rounded hat (Tsakali H, no. {za} (22)) of the fragmentary second set.

Of the colours, white is largely used for the moon cushion the deities sit on and head nimbuses. Yellow is only occasionally used for cushions, as well as for robes. Green and blue are frequently employed and can occur in any part of the image, while pink is found in almost all the paintings, though often in smaller areas. Gold is used for ornaments and patterns. Together with the skin tones, this relatively small palette of colours is effectively employed to achieve a high degree of variation, and there is no obvious pattern that can be recognised.

Overall, the paintings are executed in a crisp style that combines bold outlines with delicate shading that varies depending on the base colour. For the bodies, this shading largely follows the black outlines, but is also used to model bodily features not marked by those outlines, such as the knees and the arc of the foot. Fine shading is also employed for the textiles and lotus petals, while that of the nimbuses and cushions is often less delicate. Remarkably, the outlines of the heads are often reinforced by highlights in yellow, which for frontal figures are also used to highlight the nose ridge. Finally, gold is used for the jewellery of the figures, the ornaments of the seat, the patterning of the robes and hats, and other attributes. In the case of the more ornate second set, gold is also used for the skin of one of the teachers (*Tsakali* H, no. {za} (22)).

The high degree of variation within rather strictly defined parameters can best be observed by comparing the lotus seats across the main set. I have already noted that the lotus of Samantabhadra (centre of Fig. 5) stands out for its stem, while Tapihritsa's lotus replicates the double petals of the lotus without the stem (left part of Fig. 2). Instead of a stem, the space underneath the lower petals is rather awkwardly filled in black. This reinforces the notion that for Tapihritsa's depiction, Samantabhadra was used as a model. Otherwise, the lotus seat fills a rectangular area with three large petals that are usually coloured symmetrically. The petals are wide and often pointed, but their interior varies. Most frequently the interior mirrors the outer shape, but turns downwards and splits into a complex, fleshy central area with a ring or half circle in the centre above. In other types, the interior is simply shaded, has a smaller petal of the same shape as the main one, has a triple volute at its centre, or has a wide interior petal with a flat, dented centre. Together with colour and shading, these basic shapes are used to create the many variations of the lotus seats.

All the elements described for the set so far are hallmarks of workshop production, which is also indicated by the extensive usage of colour notations. The thick paint layer largely obscures these; I have only noticed one for the central lotus of *Tsakali* 19, no. *ra* (25) of the main set. Nonetheless, the infrared photo-

graphs⁷ reveal colour notations throughout. Using Tsakali 19, no. *ra* (25) as an example (left side of Fig. 5), the following notations can be recognised (listed as they occur from top to bottom):⁸

- *tha* for *mthing*, ‘blue’, used for the dark blue area in the top left corner and at the bottom;
- *ma* for *dmar po*, ‘red’, used for the U-shaped frame and central lotus petal;
- *nga?* (hook that looks like reversed Tibetan digit 1) for *sngon po*, ‘blue’, used for the bright blue of the nimbus and scarf;
- numeral ‘4’, used for the bright skin colour;
- *ka* for *dkar po*, ‘white’, used for the moon cushion of the seat;
- *ja* for *ljang gu*, ‘green’, used for the green band supporting the moon cushion;
- *sa* for *ser po*, ‘yellow’, used for the orange area between the green band and the lotus petals; and
- *na* for *na ros*, ‘pink’, for the outer petals of the lotus seat.

I have also compared these notations with those of Tsakali 1, no. *ka* (1; centre of Fig. 5); Tsakali 2, no. *kha* (2); Tsakali 34, no. *thi* (40); and Tsakali 58, no. *chu* (65; right side of Fig. 5), and observed the following variations:

- for no. *kha*, the hook (*nga?*) is used for the upper body of the deity, which is painted white instead of blue;
- *se* is used instead of *sa* for ‘yellow’ (no. *kha*);
- for no. *thi*, the original proportions for the seat are outlined, but then the lotus is painted higher;
- *sha*, meaning ‘flesh’, is used for the skin-coloured area (no. *chu*);
- *se* and *sa* are used for the orange areas (no. *chu*); and
- in painting *chu*, we can also observe that the hat was originally painted smaller, and later expanded over areas that had already been painted in green.

⁷ For the technical details of these photographs, see Chapter 4.

⁸ I have used the following studies for comparison: Jackson and Jackson 1984, 91–93; Duffy and Elgar 2003; and Bellucci et al. 2011.



Fig. 5: Infrared images of a siddha (Tsakali 19, no. *ra* (25)), a primordial Buddha (Tsakali 1, no. *ka* (1)) and a hatted monastic (Tsakali 58, no. *chu* (65)) of the main set showing colour notations.

4 Painting: Production and historical significance

All these formal observations raise the question of how the paintings were produced. It seems to me that as a first step, the picture area must have been defined. This was most likely done by painting it with the thin whitewash that can occasionally be observed at the edges of the paintings. From the examples I used – paintings Tsakali 2, no. *kha* (2); Tsakali 19, no. *ra* (25); and Tsakali 34, no. *thi* (40) of the main set – there is no indication that an outer line was used at this stage; instead, a single vertical line across the painted panel was used to define the centre. Horizontal lines were then added to lay out the areas of the seat and the arch of the U-shaped outer frame. There is no indication of measuring marks along the central axis of the figure or at the ends of the horizontal lines; the painter must thus have achieved uniformity of size by means that left no trace on the painting, such as finger measurements. A master painter must then have outlined the figure before completing the arches of the nimbus and the cushion that frame it, which are adjusted to the figure. Then the colour notations must have been added to the different parts before giving the painting to apprentices to start filling those in.

The succession of paint layers and final outlines is more difficult to establish. The outer yellow frame and the background of the stamen of the lotus seat must

have been one of the first layers applied, as these are covered by all the other elements. If we take the painting of Tapihritsa (Tsakali 34, no. *thi* (40); left side of Fig. 2) as an example, the white of the deity and its seat appear to have been added early on in the process. Before that, the first washes of the nimbus and cushion must have been added, as well as the back of the sky and the frame, for which an orange wash was used. With Tapihritsa, the first blue wash defining the cushion enters the left thigh area of the deity, as guided by the original outline, but then the shading is guided by the final outline of the figure. This indicates that the washes were applied first; next, the colour of the figure was painted; and then its outlines were done in red. Finally, the shading of the cushion and its black outlines were completed. These black outlines may have been done together with the eyebrows and eyes of the figure. Finally, highlights were applied to the faces and lotuses, and topped with gold for the throne ornament where the nimbus and cushion meet and for the jewellery.

In other words, there is plenty of evidence for a rather complex construction process, with multiple paint layers applied on top of each other to achieve the desired appearance. As the first washes of colour were added after the outlining, the details of the figures must have been drawn in between, and then the painting completed through shading. Prior outlines were thus not always strictly adhered to, resulting in intentional overlaps that give the paintings volume. This is most obvious from the double lotuses of Samantabhadra and Tapihritsa, which burst the frame, and the textiles.

Establishing the location and period in which this set was painted is extremely challenging. At first glance, the paintings reflect a style that is commonly associated with the fourteenth century.⁹ However, it is an archaising style, as the paintings also contain elements that only begin to be used later on, the most obvious being the voluminous depictions of the dress and some of the lotus forms, including that used for Samantabhadra and Tapihritsa. These elements document the impact Chinese painting had on Tibetan painting from the fifteenth century onwards.¹⁰ To get a clearer picture of the derivation of this style, we thus have to consider specific motifs and technical characteristics in comparison.

Stylistically, the most noteworthy features are the highlighting and the shading. By highlighting, I mean the additional yellow line that follows the contour lines in black and red. It is prominently used for the faces, but also for the lotuses. For the siddha, this highlighting is combined with a peculiar hairstyle, namely

⁹ For instance, the later paintings of Shalu are a good comparison in this regard.

¹⁰ See Jackson 1996, 103–138.

black hair with large locks. These locks are again shadowed by a fine black line, and single hairlines project from the points where the arches meet. This peculiar combination is known from the early murals in the tower of Sekhar Guthok in Lodrak (Fig. 6).¹¹ Paintings of this type or artistic school must therefore have served as a model. Of course, highlighting is also used more broadly in different manifestations of the Nepalese style (*beri, bal ris*) in Tibet, as are the large locks, but they are particularly prominent in paintings of the thirteenth and fourteenth centuries, and continued to be used occasionally afterwards.¹² In our set, their particular appearance serves as a reference to earlier styles, and thus to imply the ancientness of the set.

The peculiar shading of the halos and dress employed in the set is an aspect of its style that at first glance appears more current, but early variants can already be observed in the Sekhar Guthok murals cited above, most notably in the dress of Pagmodrupa. While in large murals such as these, the shading is hardly noticeable, at the scale of the *tsakali* set, it is much more prominent, and thus comes across as rather schematic. However, comparing the shading of the dresses used across the set shows that there is a high degree of variation within the same outlines, which serves to make them appear voluminous. For the same purpose, the dresses are folded at their edges, showing the interior side of the cloth in a contrasting colour, which is only occasionally used in a much more schematic manner. The occasional use of overlaps serves the same purpose.

As mentioned earlier, the emphasis on the volume of the dress is one of the characteristics of the emerging painting styles that incorporated elements of Chinese painting. These are first noticeable at the beginning of the fifteenth century, but gradually replace the older styles.¹³ In our set, there are several such elements besides the voluminous depictions of the dress and scarves. Most noteworthy are the lotuses deriving from the peony and cloud patterns in gold, which decorate the clothes (Tsakali 36, no. *ni* (42) of the main set (Fig. 7) and Tsakali H, no. *{za}* (22) of the second set (right of Fig. 4), used for the hat), but they are inconspicuous overall.

¹¹ See Henss 2014, 429–438. Further images by Michael Henss are available at Himalayan Art Resources, ‘MH U-Tsang 3 (Painting)’, <<https://www.himalayanart.org/search/set.cfm?setID=4430>> (accessed on 21 July 2025).

¹² See, e.g., the murals of Luri in Mustang (<https://luczanits.net/galleries/index.php?category/21>, accessed on 28 July 2025), the depiction of Milarepa at Wanla (Luczanits 2015, figs 53 and 59), and the depictions of Sönam Tsémo (1142–1182) beyond the fourteenth century.

¹³ This transition can be observed, for example, in the murals of the Gyantse monuments, from the temple in the fortress to the Kumbum, with the Kumbum incorporating the most such elements.

The variation in the depictions of the lotus petals, as described above, reinforces the overall sense one gets from the set. Most of these lotus shapes are much older than the set itself, and only the double lotus of the primordial Buddha clearly derives from the peony (centre of Fig. 5). Most unusual among the petal shapes are those with three volutes at their centre, which are used frequently. This motif first appears as a cloud interior, but in the case of the lotus petal is used more like an ornament. Such ornaments inside the lotus petals appear to emerge in the second half of the fifteenth century and can take on many shapes, most commonly a vegetal motif, a miniature lotus or jewels. I have not succeeded in finding any direct comparison for this cloud motif within a lotus petal, but some of the murals in the Gyantse Kumbum may well represent an intermediary. In this case, the peony-derived double lotus has interior petals with three volutes in its interior (Fig. 8).

As noted above, the outline of the teacher's outer dress is alike in all cases. This mantle envelops the body and covers the front of the legs, with the cloth falling from the right shoulder and hanging in front of the figure. While this representation of the garment becomes one of the most frequently used, a close early comparison is found in a painting set, commissioned by Ngorchen Kunga Zangpo in memory of his teacher Buddhaśrī, in which the Sönam Tsémo (1142–1182) and Drakpa Gyeltsen (1147–1216) are dressed in this way (Fig. 9).¹⁴ This comparison is significant not only because it can be dated to the second quarter of the fifteenth century, but also because here it is used for larger-size figures in a way that still reflects the symmetrical framing of the figure as used in earlier painting. In other words, it represents an earlier form than we have in the set.

¹⁴ See Heimbel 2017, plates 5–7, for three paintings known from this set, the relevant one being the last; or Himalayan Art Resources, 'Item: Teacher (Lama) – Sonam Tsemo' (item no. 87230), <<https://www.himalayanart.org/items/87230>> (accessed on 21 July 2025) and 'Painting Set: Margapala [2] (Ngorchen)' <<https://www.himalayanart.org/search/set.cfm?setID=1022>> (accessed on 21 July 2025), for four paintings from the set.



Fig. 6: Comparison between the representation of Marpa at Sekhar Guthok and the siddha on Tsakali 16, no. *za* (22) of the main set; photo: Marpa by Heather Stoddard, 2000.

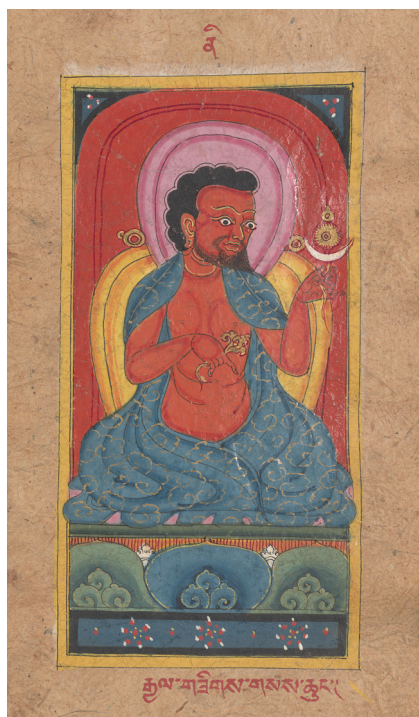


Fig. 7: Tsakali 36, no. *ni* (42), with a bearded siddha wearing an outer robe with a cloud pattern and lotus petals with three volutes at their centre.



Fig. 8: Bodhisattva Vajradharma in the Gyantse Kumbum; photo: Robert N. Linrothe, 2005.



Fig. 9: The Sakyapa hierarchs Sönam Tsémo (1142–1182) and Dragpa Gyaltsen (1147–1216), from a set depicting the lineage of teachers of the ‘path’ together with the ‘result’, commissioned between 1419 and 1430 by Ngorchén Kunga Zangpo as part of the funerary services for his teacher Buddhaśrī. Tibet, distemper on cotton, 84.0 × 78.2 cm (33¹/₁₆ × 30¹³/₁₆ in.); Boston, MA, Museum of Fine Arts, Gift of John Goelet 67.831. © 2025 Museum of Fine Arts, Boston.

An unusual feature of the *tsakali* set is the way the beards are rendered with clusters of hair on the cheeks and the main beard pointed and projecting forward (Fig. 6). In this case, there is a close comparison with an enigmatic *tsakali* set at the Rubin Museum of Himalayan Art that otherwise has completely different

stylistic characteristics (Fig. 10).¹⁵ Likewise, the rendering of the hats worn by the teachers is unusual, their rather awkward appearance probably being due to perspective distortion. Here, too, direct comparisons are lacking.



Fig. 10: Bearded teacher, identified as Nagarjunagarbha, from an enigmatic *tsakali* set at the Rubin Museum of Himalayan Art, New York, NY.

¹⁵ For this set, see Himalayan Art Resources, 'Item: Miscellaneous – (unidentified)' (item no. 734), <<https://www.himalayanart.org/items/734>>, for the example referred to here, and 'Initiation Cards: Nyingma Lineage Card Set', <<https://www.himalayanart.org/search/set.cfm?setID=120&page=1>> (accessed on 21 July 2025) for the full set. While it is said that the paper of this set is carbon dated between 1174 and 1293, the painting itself must be considerably later and may well be no earlier than the set we are discussing here. Amy Heller, in her description, takes no position in this regard.

Finally, the flask on the damaged Tsakali 0 is beautifully rendered. It has a heart-shaped body with a spout and a base of elongated lotus petals. Golden lotus petals also appear to hang from the upper white scarf, while the lower scarf falls in an elegant loop around the body. This is a relatively modern shape that is still used today, but it is unclear to me when this shape first took hold.

Overall, the comparisons hint towards a date in the early sixteenth century at the earliest, as only then could the disparate elements observed have come together in this form. Being archaising throughout, the set might also be from somewhat later within this century, while a seventeenth-century date, still possible according to the ¹⁴C test, appears unlikely to me (for the radiocarbon dating, see Chapter 10).

Where the set was made is even more doubtful. The workshop must have been active in an area with a rich tradition of *beri* painting, an area of southern Tsang (gTsang) appearing most likely. Given the quality of the workmanship, there must have been an artistic centre for Bon art in that region. It may also be that they were produced by artists who otherwise made Buddhist art, as most features of the set are directly comparable.

Kyle Ann Huskin, Ivan Shevchuk

Chapter 4: Multispectral Imaging (MSI) and Statistical Image Processing to Analyse Pigment Distribution and Diverse Material Features

Abstract: The multispectral imaging (MSI) data from the *tsakalis* was performed as a preliminary analysis to assist the work of other researchers involved in the project. Statistical processing of the spectral data identified potentially different pigments and thereby guided the measurements with X-ray fluorescence (XRF) and Raman spectroscopy. The infrared transmissive images showed the cards' paper structures for further analysis with microscopy and Fourier-transform infrared spectroscopy (FTIR). The high-resolution, accurate-colour images also served as a basis for palaeographic and art-historical study, as well as for computational pattern analysis work. The infrared reflectance images also revealed pre-drawings and symbols beneath the various colours, shedding light on the cards' production method. This chapter explains MSI as a method and discusses the findings related to pigment anomalies, underlying drawings and symbols, and paper structures.

1 Introduction

As a non-destructive and non-invasive method, multispectral imaging (MSI) is the go-to approach for recovering erased, palimpsested, or otherwise obscured text or features and has proven remarkably effective for this purpose.¹ MSI can also be an effective tool to begin to study an object's materiality because it produces a diverse set of images with decent spectral resolution and excellent spatial resolution

1 The 'Archimedes Palimpsest Project' of the early 2000s was the first MSI project to use digital photography and statistical processing methods, and its remarkable results established MSI as the go-to method for palimpsest text recovery (Netz and Noel 2007, 205–232; Easton and Noel 2010). More recently, MSI successfully recovered the undertext in Cambridge University Library's Codex Zacynthius (Houghton and Parker (eds) 2020; Easton et al. 2020). Useful for revealing more than text, MSI also uncovered spectacular drawings in Wolfenbüttel, Herzog August Bibliothek, Codex Guelf 125 Gud. lat. (Carmassi 2017). Similarly, MSI data from London, British Library, Cotton Nero A.x not only recovered damaged text and illustrations, but also revealed underdrawings and pigment anomalies (McGillivray and Duffy 2017).

that can easily facilitate different avenues of research.² In the case of the *tsakalis*, MSI was performed with the latter goal in mind because they had no known illegible or obscured features.

The MSI results successfully guided and enabled the work of the other researchers and scholars on this project. For instance, 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 drew attention to differences among the cards’ paper structures that were further explored with microscopy and Fourier-transform infrared spectroscopy (FTIR) (see Chapters 6 and 8, as well as the appendix). The high-resolution, accurate-colour images also fulfil all the typical needs of archival digitisation and thus served as a basis for palaeographic and art-historical study (see Chapters 1 and 3), as well as for computational pattern analysis work (see Chapter 5). Unexpectedly, the infrared reflectance images revealed letters beneath the various colours – a kind of paint-by-numbers system – that was also of great interest to those analysing the pigments and the *tsakalis*’ production methods.

2 Equipment and principles of MSI

All of the sixty-five *tsakali* cards were imaged in November 2021 by Ivan Shevchuk and Kyle Ann Huskin with the Centre for the Study of Manuscript Cultures’ MegaVision EV™ camera fitted with the 50-megapixel E7 sensor and a 120mm f/4.5 apochromatic lens.³ As per the usual setup, two equidistant tripods with three LED light panels each were stationed on either side of the camera. The panels illuminate in nineteen different wavelengths of light in the ultraviolet (UV), visible (VIS), and near infrared (NIR) parts of the electromagnetic spectrum, specifically from 365 to 1050 nanometres (nm). Two filter wheels mounted in front of the lens are used in combination with the UV wavelengths for the fluorescence part of the sequence. A customised LED light sheet is placed beneath the object to shine light at VIS and IR wavelengths through it. This setup allows us to capture up to fifty

² Janke et al. 2024 demonstrate that MSI can effectively reveal anomalous material features that merit further analysis with more specialised tools, such as XRF and FTIR.

³ The system setup remains the same except that we have since upgraded to MegaVision’s 150-megapixel Q15 camera sensor (see <<https://mega-vision.com/products/ev-spectral-imaging-system/>>, accessed on 22 July 2025).

greyscale images in four distinct imaging modalities: reflectance, fluorescence, raking, and transmissive.

The first two modalities – reflectance and fluorescence – are invaluable for text recovery and beneficial for ink and pigment classification. As the name suggests, the reflectance images capture light as it reflects off the surface of the object and into the camera lens. Specifically, the LEDs illuminate the object at 365, 385, 400, 420, 450, 470, 505, 530, 560, 590, 615, 630, 655, 700, 735, 780, 850, 940, and 1050 nm. These images are calibrated on a white Labsphere Spectralon[®] diffuse reflectance target, which reflects 99 per cent of light across the 350–1100 nm range detectable by the silicon camera sensor. Because humans can only see from roughly 400 to 700 nm, the reflectance images already reveal more information about the object than visible light alone. For instance, the three main ink classes (plant, iron-gall, and carbon inks) exhibit dramatically different optical properties in the NIR region.⁴ Likewise, the calibrated reflectance images – now reflectance data – enable a more comprehensive analysis of an artist's colour palette when researchers inspect the distinctive behaviour of some visually similar colours in the visible and invisible regions.⁵ Finally, a highly accurate colour rendering is generated from the reflectance data by combining nine visible-light images. Using a Macbeth ColorChecker for colour calibration, these images are combined to produce a rendering in the LAB colour space – dubbed 'PSC' (Photoshoot Colour).

Fluorescence data is captured in up to twenty-two images when high-energy UV and blue light (365, 385, 400, and 450 nm) illuminates the object and excites its electrons into a higher energy level, causing them to decay and emit light at lower-energy wavelengths (i.e. in the VIS and NIR regions) depending on its features' material properties. The commonest manuscript substrates (e.g. parchment, paper, papyrus) readily fluoresce or 'glow' when illuminated with these wavelengths. The four fluorescence illuminations are combined with six filters (UV block (Schott GG400), UV pass (Hoya U360), orange (Wratten O22), red (Wratten R25), green (Wratten G58), and blue (Wratten B47)) that selectively prevent or permit certain wavelengths from reaching the camera sensor, improving the ability to distinguish amongst inks, stains, pigments, etc. Fluorescence data is invaluable for recovering faded and erased text written in plant and iron-gall inks, both of which penetrate deep into the substrate; even imperceptibly small amounts of remaining ink will quench the substrate's fluorescence, making it reappear against the

⁴ See Mrusek, Fuchs and Oltrogge 1995, 72.

⁵ McGillivray and Duffy 2017, 133–143, for example, use the 940 nm image to identify the presence of two red pigments (vermilion and what is presumed to be minium (red lead)) in the *Gawain* manuscript's illustrations.

glowing background. Fluorescence data can also be combined with infrared images to preliminarily identify some pigments if it can be compared to suitable reference target data.⁶

The final two imaging modalities – raking and transmissive – are more important for studying an object’s materiality. Raking lights are placed at a 10–15° angle to the object and fired separately from the left and right panels at 450 and 940 nm, producing four images that enhance topographical features, such as erasures, scraping, cockling, etc. The final four images are captured when transmissive light is shone through the object at 500, 580, 735, and 940 nm to reveal substrate features, such as parchment thinning from ink corrosion or erasures, papyrus fibre structure, watermarks, chain and laid lines, and paper fibres.

3 Statistical image processing

After data capture, we use statistical image processing (or simply ‘processing’) to extract specific information from the greyscale images. An image cube with forty-two bands is created by digitally stacking the reflectance and fluorescence images. Every pixel has a numerical value from 0 to 4095 due to the camera sensor’s 12-bit dynamic range. Because the images are registered, every pixel in every image refers to the same manuscript feature, and the pixels’ changing numerical values correspond to the material’s spectral changes across the wavelengths. This ‘pixel dimensionality’ allows us to use various statistical and algorithmic methods to enhance a given feature of the manuscript, typically the obscured text.

For both materials analysis and text recovery, the most consistently useful processing methods are Principal Component Analysis (PCA) and Independent Component Analysis (ICA).⁷ The PCA algorithm assumes a linear distribution of the dataset’s statistics and uses an uncorrelated (orthogonal) transformation to reduce the dimensionality of a large dataset, such as an image cube, and reorder the information according to degree of difference, represented visually as contrast. The resulting PCA cube has a first band in which the most spectrally dissimi-

⁶ Cosentino 2014, 4–9.

⁷ For more on these methods’ use in text recovery, see Easton and Kelbe 2014, 39–45. For more on ICA specifically, see Hyvärinen and Oja 2000. In this study, ICA was performed in ENVI Classic 5.7 from L3Harris Geospatial Solutions, Inc.

lar features (e.g. black and white pigments) are represented with the highest contrast, while the second band shows the second most dissimilar features (e.g. black or white pigments and another colour) with slightly less contrast, and so on. Unfortunately, manuscripts' highly heterogeneous features – e.g. stains, inks or pigments with variable thicknesses, flaking inks, overlapping pigments, irregularities in the substrate's texture or colouring, etc. – make it difficult for PCA to completely separate and accurately order the information.

We typically turn to ICA for features separation. ICA transforms the data based on higher-order statistics (e.g. kurtosis and negentropy) and reorders the data non-linearly according to degree of statistical independence. ICA is thus especially useful for separating mixed signals, extracting features, or identifying independent underlying patterns. It works well for manuscript analysis because the different inks and pigments on a page are essentially independent sources due to their unique spectral properties, and the MSI image cube contains the mixed signals of these independent sources. For this reason, ICA was chosen over PCA to compare the pigments used on the *tsakalis* in selected three-card datasets.⁸

4 MSI results for the *tsakalis*

4.1 Pigment distribution analysis

ICA was run on the nineteen calibrated reflectance images using a region of interest (ROI) on the middle *tsakali* in each of three selected datasets with the goal of 'mapping' pigments in each dataset,⁹ and spectral reflectance curves were also generated to supplement the ICA results. In most cases, the output ICA bands successfully isolated different coloured regions. In the case of red- and green-coloured areas, ICA indicated that different pigments may have been used for features that appear visually very similar. Combined with the spectral reflectance curves, the results conclusively demonstrated that two different green-coloured pigments (hereafter 'green' and 'teal-green') were used, but no solid conclusions could be drawn from the MSI data alone about the reds.

⁸ Baronti et al. 1998, 1303–1309, show the potential for pigment mapping using PCA on MSI images. From what we know of ICA, it should work even better to separate pigments.

⁹ All MSI data for the *tsakalis* are available in Shevchuk and Huskin 2024.

The first stage of analysis was comparing the ICA results to the colour image. We see in Figs 1a–h that several ICA bands clearly distinguish amongst the coloured regions in this dataset, including the blues, yellows, reds, and gold. However, we see in Fig. 1b that the algorithm did not separate but rather grouped the black outlines, borders, and hair with the teal-green areas in the cloud and leaves on Tsakali 0 recto, the lotus petal decoration (on which the Yenyid kyis ston pa figure sits) on Tsakali 1 recto, and the mandorla and skirt on Tsakali 2 recto. Such grouping indicates that both colours have similar spectral responses. With Figs 1b and 1c, it becomes apparent that the green used for the leaves on Tsakali 1 recto, and for the deity figures' bases on Tsakali 1 recto and Tsakali 2 recto, should probably be distinguished from the teal-green used elsewhere – a sometimes-subtle colour distinction that may not be immediately apparent to the naked eye and something suggestive of different pigments. Moreover, there is noticeable confusion amongst the red areas in Figs 1e and 1f, raising the question of whether a different pigment could have been used for the background on Tsakali 2 recto, as well as whether different reds might have been used in the lower decorations across Tsakali 0 recto, Tsakali 1 recto, and Tsakali 2 recto.

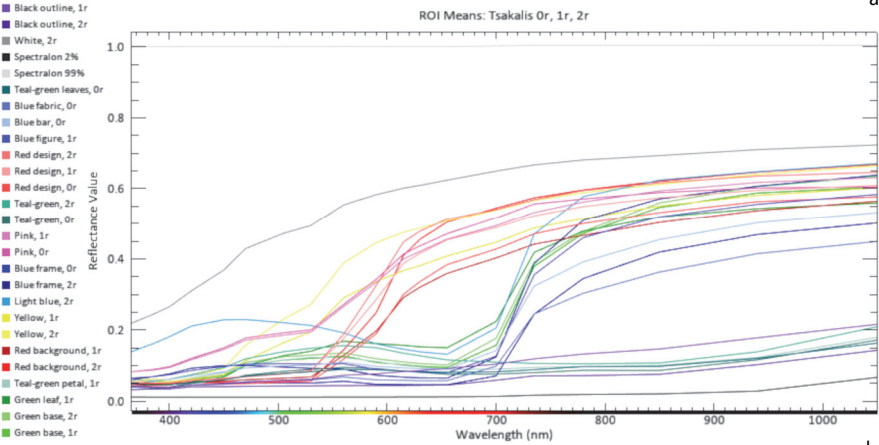
The second stage of analysis was to create spectral reflectance curves for different coloured areas, focusing on those regions ICA identified as suspicious. We see in Figs 2a–b that the curves for each colour behave essentially the same regardless of where it was sampled. A striking exception occurs with the teal-green and green, which can appear visually quite similar: whereas the reflectance values for the green areas increase sharply at 655–700 nm, the teal-green areas' values remain low in the IR region. The 1050 nm images also confirm the colours' very different behaviours in wavelengths invisible to humans (see, for example, Figs 3a and 4b). These data strongly suggest that different pigments were used for the green and teal-green. For these pigments, then, MSI has been proven sufficient for preliminary pigment analysis, though it cannot identify the two pigments without supporting results from XRF and/or Raman spectroscopy.



Figs 1a–h: (a) PSC image of Tsakali 0 recto, Tsakali 1 recto, and Tsakali 2 recto; (b) ICA band 1, highlighting blacks and teal-greens; (c) ICA band 7, highlighting greens; (d) ICA band 10, highlighting gold; (e) ICA band 4, highlighting reds; (f) ICA band 9, highlighting reds and red-oranges; (g) ICA band 6, highlighting yellows; (h) ICA band 13, highlighting blues.



a



b

Figs 2a–b: (a) Selected ROIs shown as polygonal coloured areas, in circles, on the ENVI-generated RGB image of Tsakali 0 recto, Tsakali 1 recto, and Tsakali 2 recto; (b) spectral reflectance curves based on the mean ROI values.

Based on the ICA results in Figs 1e and 1f, we might also expect to see significant differences in the spectral reflectance curves for the two red background regions, as well as among the regions for the red decorations. The fact that all of the curves for their respective features follow similar trajectories, however, throws this assumption into doubt. These conflicting results highlight the limitations of reflectance MSI for pigment analysis.¹⁰ All red pigments necessarily have similar reflectance curves in the VIS range, and MSI does not have the fine spectral resolution necessary to distinguish among them.¹¹ For this reason, we cannot say if ICA is picking up some meaningful statistical difference that goes unnoticed in the spectral reflectance curves, such as different pigments or binders, or if ICA is amplifying some slight statistical variations that actually are not meaningful when it comes to pigment classification, such as variable thickness of pigment application or the relative cleanliness of the cards' surfaces. In this case, further analysis with XRF and/or Raman spectroscopy is needed to explain what, if anything, is causing these conflicting results in the MSI data.

Although the pigment distribution results were partially inconclusive, the MSI results were still immensely beneficial for highlighting suspicious features and guiding the initial XRF and Raman spectroscopy measurements so that these time-consuming methods can be used most effectively (see Chapter 9).

4.2 Pre-drawings revealed

Infrared wavelengths can penetrate thin layers of materials, such as a single layer of paper or most thinly applied pigments, more easily than visible light. For this reason, infrared reflectography (IRR), which typically operates in the 900–1700 nm range, is often used to visualise pre-drawings of paintings because those are usually done in with carbonaceous materials, such as graphite, which absorb light in the IR region.¹² The MSI data captured at 940 and 1050 nm did indeed reveal the *tsakalis*' pre-drawings (see Figs 3a–b). Unexpectedly, the images also revealed

¹⁰ Cosentino 2014, 10, also struggles to differentiate red pigments with his UV-VIS-IR combinations and flowchart method. McGillivray and Duffy 2017, 133–143, could distinguish between vermilion and the suspected minium because an oxidised minium, like our teal-green and unlike vermilion, should remain dark throughout the IR region.

¹¹ Pigment mapping would probably be more successful with the higher spectral resolution of a hyperspectral imaging (HSI) system, which would capture over one hundred bands in the 365–1050 nm range. Bai, Messenger and Howell 2017, for example, found multiple kinds of visually similar red pigments on the Gough Map using Gram matrix analysis of HSI data.

¹² Delaney et al. 2016, 6–8.

characters under the main features of every *tsakalis*' illustration, and, upon closer examination, they seemed to refer consistently to the colours applied on top of them (see Figs 4a–c, as well as the more detailed explanation of the scheme in Chapter 3, 46–58).

The pre-drawings shed light on the *tsakalis*' production. They seem to suggest the following process: first, an artist drew with a carbon ink¹³ the rectangular image frame, a line down the centre to aid symmetry, and outlines for the figures and most of the decorative elements in the same ink; next, the colours were laid down; and finally another layer of carbon-ink outlines were drawn or redrawn around the final image.¹⁴ In Figs 3a–b showing fragments of Tsakali 1 recto, for instance, we can clearly see conflicting outlines in the IR images, most notably on the top curve of the Ye nyid kyis ston pa figure's nimbus and on his left leg and foot. Taking the nimbus (mandorla) as the clearer reference, it would appear that an artist laid down an initial, flatter outline in black ink; then the composition was altered intentionally or unintentionally when the pink and red layers were applied; and finally, the black outlines were redrawn according to the revised design.



Figs 3a–b: (a) Pre-drawings on Tsakali 1 recto revealed with the 1050 nm image, with PSC image for reference; (b) close-up of the pink nimbus region.

¹³ The fact that the pre-drawings (and the letters, for that matter) appear dark in the IR and are absent in the XRF element maps indicates a carbonaceous composition.

¹⁴ The full complexity of the production process is detailed in Chapter 3, 49–57.

Significantly, the IR images also uncovered letters that correspond to the colours in the illustration, suggesting that a kind of paint-by-numbers system was used in the production process. As shown in Figs 4a–c, this system is most clearly visible on Tsakali A recto because its intricate illustration utilises every colour from the whole *tsakali* set, but it appears consistently on every card. A system like this seems necessary only if the person designing the cards' initial layout, which includes these letters and the first layer of outlines, is different from the person applying the colours and final outlines. The IR images produced as part of the MSI analysis therefore provide valuable information for the art historians (see Chapter 3).

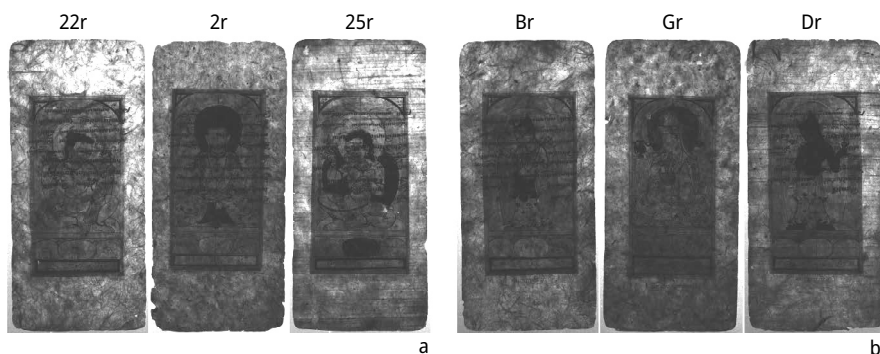


Figs 4a–c: (a) A catalogue of letters, taken from Tsakali A recto and Tsakali 0 recto, and their corresponding colours; (b) letters revealed on Tsakali A recto with the 1050 nm image, with the PSC image for reference; (c) letters denoting yellow revealed on Tsakali 0 recto with the 1050 nm image, with the PSC image for reference. Note: there is probably a symbol designating teal-green as well as green, but it may be invisible because the overlaid colour is equally dark at 1050 nm.

4.3 Paper structure

The IR transmissive light images reveal what appeared to be three distinct types of paper: two types with inhomogeneous structures, randomly oriented fibres, and no visible laid lines, of which one type shows a lower and the other a higher

fibre density; and one with horizontal laid lines.¹⁵ As shown in Figs 5a–b, the different paper types are present in both stylistic sets of *tsakalis*. Further analysis with microscopy and FTIR was, of course, necessary to understand crucial information about the paper, such as the fibre types used and the presence of additives, fillers, and sizing agents. Nevertheless, the MSI transmissive images offer some distinct advantages over the standard LED transmissive white light sheet for paper analysis. First, the paper structures are revealed better because of the better penetration properties of IR wavelengths than visible light. Second, the captured transmissive images are registered with the rest of the MSI data and allow for further visualisations by simply overlaying them with the reflectance data. Finally, the captured images allow anyone with the dataset, including the original researcher, to repeat the observations at any time.¹⁶



Figs 5a–b: (a) Transmissive light images (940 nm) of three *tsakalis* from the first stylistic set showing, from left to right, the paper with lower-density fibre structure, with higher-density fibre structure, and with horizontal laid lines; (b) transmissive light images (940 nm) of three *tsakalis* from the second stylistic set showing the three types of paper in the same order.

¹⁵ Later analysis (see Chapters 6 and 8) determined that there are two types of paper: a woven type with two subsets, one with a lower-density fibre structure and one with a higher-density fibre structure, and a laid type with horizontal lines.

¹⁶ Cf. McGillivray and Duffy 2017, 125.

5 Conclusion

MSI was successfully deployed as the first method of materials analysis on the *tsakalis*. The spectral data in the reflectance images, combined with statistical image processing, were able to distinguish conclusively between two sometimes very visually similar pigments – green and teal-green – and to raise questions about red pigments that guided further analysis with XRF and Raman spectroscopy. The IR images revealed not only pre-drawings but also letters indicative of a paint-by-numbers system hidden underneath the pigment layers, giving the art historians valuable new information. The transmissive images also assist paper analysis by providing a broad, repeatable overview of the entire *tsakalis* collection's substrates.

Hussein Mohammed, Agnieszka Helman-Ważny

Chapter 5: Analysing the Visual Patterns of the Zhangzhung Nyengyü *Tsakali* Collection Using Machine-Learning Approaches

Abstract: This research forms part of a broader study that seeks to uncover the obscure history of the production and use of the Zhangzhung Nyengyü *tsakali*, or initiation cards, employed in various Tibetan rituals. This study employs multiple pattern-analysis techniques on the digital images of this collection to address specific research questions. In this work, the similarity between handwriting is analysed using the handwriting analysis tool (HAT); the sieve print of the writing support is analysed using the line detection tool (LDT); and the subjects depicted in *tsakali* are detected using the visual-pattern detector (VPD). These software tools were developed for manuscript analysis at the Centre for the Study of Manuscript Cultures. The initial findings highlight the potential for pattern analysis and its relevance to manuscript research, especially in the context of large collections. We briefly describe the methods used and discuss the preliminary results obtained from each.

1 Introduction

In recent years, automatic pattern analysis using machine-learning approaches has emerged as a potent and valuable tool for studying written artefacts when developed and applied properly. Such methods should be developed with close consideration of the actual research questions arising from manuscript studies, rather than relying solely on standard datasets and evaluation metrics devised by computer scientists in isolation. Furthermore, the application of these methods and the interpretation of their results should be undertaken in direct collaboration with domain experts in manuscript studies.

Several works have been published by computer scientists on the analysis of historical manuscripts using computational approaches, few of which can be easily and independently used by scholars. On the other hand, pattern analysis

software tools (PAST)¹ comprise a suite of scientific software tools designed for the analysis of both visual and tabular patterns in data derived from the study of ancient written artefacts. Each tool in this set is designed to have an easy-to-use graphical user interface (GUI). Furthermore, each tool is tested by relevant experts from manuscript studies. Therefore, we employed three tools from PAST in this case study to analyse the handwriting styles, writing supports and drawing instances within the collection of sixty-five Zhangzhung Nyengyü *tsakali*. The initial results of our study underscore the potential for pattern analysis and its extensive applicability in the field of manuscript research.² In this chapter, we will focus on the discussion and interpretation of the results and their influence on the next phases of this research. As stated in Chapter 1, this set of *tsakali*, despite similarities in style, may contain cards that may have been added to the collection later. We also know that *tsakali* were usually used in sets, depending on their purpose or user. There is a large number of cards of a similar style, preserved in the Triten Norbutse Monastery in Kathmandu, that may be a good reference for future research. We cannot exclude the possibility that some of the cards preserved in Triten Norbutse are part of our studied collection as well. Thus, there is a need for automatic pattern analysis in order to allow for the efficient search and quantitative comparisons of different sets based on particular features.

The *tsakali* are not bound and can easily be mixed with other sets of the same size. Moreover, the objects and figures depicted on the cards are chosen for specific types of performances, making each collection unique. Thus, we do not know whether these sixty-five cards comprise a full set or were just accidentally separated from a much larger collection or collections. As computational methods are good for working with large amounts of data, they are helpful in this study.

The starting point for our research is to produce images of a sufficient quality that can be used for further processing and analysis. The photographs produced with MSI, as described in Chapter 4, were very appropriate for our purposes. The digitisation process resulted in high-resolution TIF images. Each image contains three cards, and every card has a resolution of about 2280×4870 pixels. The average height of the letters in these images is around 60 pixels, which is sufficient for a proper analysis of the handwriting.

1 Mohammed et al. 2022. The PAST software can be downloaded from <<https://www.csmc.uni-hamburg.de/publications/software.html>> (accessed on 29 July 2025).

2 The technical details and mathematical descriptions of these experiments have been published in Mohammed and Helman-Ważny 2022.

2 Handwriting style analysis

The *tsakali* have a very specific ritual function. Each card displays both an image, described underneath in red ink on the recto side, and a longer text written in black ink on the verso. The text on the verso is inseparable from the image and varies in length from card to card, written in the headless *ume* (*dbu med*) script in black and red ink.³ This script is not standardised and displays the idiosyncrasies of individual scribes. Therefore, analysing the handwriting styles with the handwriting analysis tool (HAT)⁴ can be useful in determining whether all the cards were written by the same person. Identifying different scribes can thus shed light on the production process and the artisans involved. The results of this analysis will be corroborated by other methods, such as paper and pigment analysis.

The HAT is utilised for this analysis to measure the similarity between handwriting styles on different pages. This software tool leverages the training-free Normalised Local Naïve Bayes Nearest Neighbour (NLNBNN), facilitating the analysis of handwriting styles without requiring any labelled data, which was unavailable in this case. Several hundreds of visual features have been automatically detected and mathematically described using this tool on the contours of the ink trace. After that, a similarity score is calculated by the software for each handwriting style (scribe), providing the user with a relative comparison between the styles against a given unknown handwriting.

In this test, the similarity between handwriting on both the recto and verso sides of all sixty-five cards was measured. The results indicate that the handwriting on all sides of all images is very similar overall. Nevertheless, the similarity value of the handwriting on the verso sides of Tsakali G and Tsakali H is always half (or less) compared to all other instances; refer to Figs 1a–b. Consequently, a second test was conducted to assess the similarity of the handwriting on the verso sides of Tsakali G and Tsakali H with that on the verso sides of all the other cards' images. This test revealed no significant similarity with any image in the collection, indicating the possibility that the handwriting on these two surfaces might belong to a different scribe. Further investigation was undertaken by other, independent methods to confirm this hypothesis.⁵

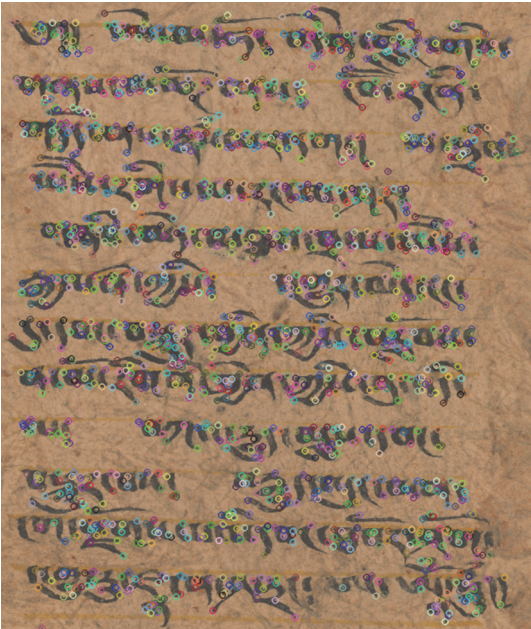
The amount of handwriting on each card is only a few lines of text. This is typically not enough for training-based approaches, but sufficient for training-free

³ See Chapter 1 for translation.

⁴ Mohammed 2020a, software.

⁵ See Chapters 3 and 10.

machine-learning methods. Nevertheless, the results of any handwriting style analysis need to be interpreted very carefully, and the wider context of the analysis must always be considered.



a

Results for Tsakalis_19_20_21_v_PSC_P1

Rank	Directory	Score
•		•
•		•
•		•
•		•
19	Tsakalis_37_38_39_v_PSC_P2	3.6
20	Tsakalis_25_26_27_v_PSC_P2	3.6
21	Tsakalis_3_4_5_v_PSC_P2	3.1
22	Tsakalis_g_h_v_PSC_P2	0.8

b

Figs 1a–b: Results of handwriting style analysis using HAT. (a) Example of an analysed page. The coloured circles represent the location of the detected features on the ink trace of the handwriting. (b) One of the similarity scores generated by HAT, which shows the small similarity value with the text executed on the verso sides of Tsakali G and H compared to all the other cards in the collection.

The results generated by HAT are relative to the samples used in the analysis, and the summation of all similarity scores is always 100 per cent. This means that using different samples from the same scribes can lead to slightly different results, and adding or removing styles will affect the absolute values of the similarity measures, but not the relative similarity between any pair of samples.

If a sufficient number of samples is made available from other card collections in the region, one can group these samples by scribe based on the similarity values between their handwriting styles. Nevertheless, one must consider the fact that the handwriting styles of different scribes can share visual features due to several factors, such as sharing the same scriptural culture or mimicking a certain scribe or school of writing.

In this experiment, we iterated over all the folios, comparing each current folio against all others. The results consistently indicated that the similarity value for this folio was always half or less than the value for any other folio in the dataset. The results indicate that the handwriting on all sides of all images is very similar overall. Nevertheless, the similarity value of the handwriting on two particular surfaces, identified as the verso sides of Tsakali G and Tsakali H, is always half (or less) compared to all other instances (refer to Figs 1a–b).

The strings in the ‘Directory’ column represent the exact folios in this dataset. As can be seen, this comparison has been done between twenty-two folios. Consequently, a second test was conducted to assess the similarity of the handwriting on the verso sides of Tsakali G and Tsakali H with the verso sides of all the other cards’ images. This test revealed no significant similarity with any image in the collection, indicating the possibility that the handwriting on this page might belong to a different scribe.

3 Writing-support analysis

The cards were created by one or sometimes more laminated sheets of paper typically produced in the Himalayas.⁶ However, two types of papermaking sieve print were detected during preliminary macroscopic observation of the analysed set,⁷ and confirmed by multispectral imaging (MSI) and statistical image processing,⁸ which suggests that more than one type of papermaking mould was

⁶ See Chapter 6.

⁷ See Chapter 1.

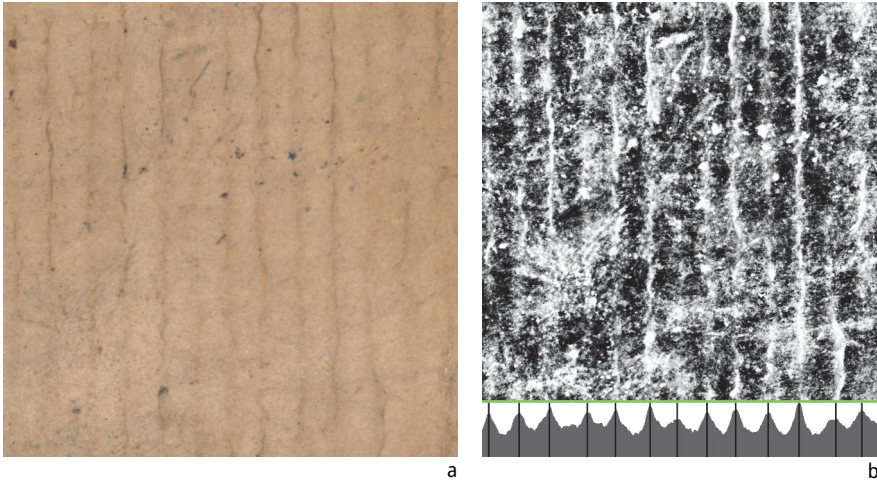
⁸ See Chapter 4.

used in the papermaking process. Besides raw materials, paper can be distinguished by technological features that originate directly from the papermaking process. The actual method of making paper in Tibet seems to have evolved very little over the centuries, with each sheet of paper made and then dried on an individual papermaking mould. This mould type is called ‘floating’ because it is placed on a water surface such as that of a lake, pond, river or, later, a wooden basin. It is usually made of a wooden frame with a thin cotton cloth spread on it. Thus, the detected marks of laid lines were unusual and suggested the use of an additional type of mould that was not typically used in Tibet. It is however important to note that the other type of technology is identified increasingly often during the examination of paper macroscopic features in Tibetan books. Significant numbers of ‘laid papers’ were found in Tibetan books in the Dunhuang collection, as was also the case for more recently studied types of paper used in Mustang and Dolpo manuscripts. This is why we used the line detection tool (LDT)⁹ to find out how many types of paper were used in this collection. The presence of laid paper in the collection could support the hypothesis that the paper used for making this set of *tsakali* could have been acquired from more than one source.

The LDT is used to analyse the writing supports in these images. This tool is based on the method described as follows: the contrast of the selected images is first enhanced using contrast limited adaptive histogram equalisation (CLAHE).¹⁰ The goal of utilising this approach is to reduce the interference of background texture and enhance the visibility of the lines in the writing support. After that, the lines are detected and localised by calculating the vertical projection of pixel values in the image. Although this approach assumes the lines to be mostly straight and parallel to each other, its utilisation is justified due to the uniform nature of these lines. The limited irregularities and distortion found in the calculated projections are rectified by a smoothing technique, namely a Gaussian filter. Finally, a histogram is constructed from the smoothed projections in order to locate the peak for each line, which refers to its estimated location in the writing support (Figs 2a–b).

⁹ Mohammed 2020b, software.

¹⁰ Pizer et al. 1987.



Figs 2a–b: Results of the writing-support analysis. (a) One sample from the analysed images. (b) The histogram automatically generated by LDT.

A square region of 30×30 mm has been analysed from three different samples using the LDT. Several measurements have been calculated automatically for all samples, such as the estimated density and spacing of detected lines. The lines observed in Tsakali D have slightly less density, which might indicate the use of a different papermaking source (see Chapter 6). The integration of results from different types of analysis and the comparison with results from other collections can lead to better interpretations of these findings.

Since these measurements are absolute and unique to each type of writing support, they can be directly compared with samples from other collections to support the study of paper production in the region. While the colour images of this particular collection were sufficient to detect the sieve line, the visibility of these lines was clearly better in some bands of the MSI images. This observation might prove handy in cases where colour images are not sufficient for the analysis of some collections.

4 Drawing-elements analysis

The *tsakali* are used in numerous ritual situations, such as empowerment rites, ritual mandalas, the transmission of teachings, substitutes for ceremonial items,

visualisation aids and funerals. The subjects depicted in the *tsakali* cover a vast range, from main deities and protectors to their various power attributes and appropriate offerings (see Chapter 3). Detecting these visual elements in different instances, and maybe in other collections, can greatly facilitate the retrieval process of relevant semantic content.

The visual-pattern detector (VPD) is used in order to detect and allocate the relevant visual elements without the need for any ground-truth annotations. This tool is based on a method that detects distinctive features in every visual element and learns the spatial relations between these features and the estimated centre of this element.¹¹ After that, a saliency map is constructed based on the features detected and their similarity to the original query image. This saliency map is used to allocate and identify the visual elements in each image.

Only one example is used per pattern in this analysis, as the method used is a training-free approach. The VPD detects similar visual patterns in this collection automatically without the need for any annotations, and the recall-precision balance of detected patterns, which is the main parameter for most pattern detection approaches in machine learning, can be intuitively controlled using visualised examples. The pattern in Figs 3a–c is a bowl made of a human skull. Such human-skull bowls were often used in Tibetan rituals.

Given the small number of images in this collection, one can, with a reasonable amount of effort and time, search manually for visual patterns and objects without any support from computational methods. But this collection is only one of many other collections from the same region, and possibly other neighbouring regions. Searching for similar visual patterns across collections can help in revealing new insights about the practices, interaction and transmission of these cultures. Furthermore, the exact measure of similarity between detected patterns can be used in order to evaluate and quantify gradual changes across space and time.

¹¹ Mohammed 2021, software.



Figs 3a–c: Example results from VPD presenting three automatically detected instances of human-skull bowls.

5 Discussion and conclusions

In this study, we applied machine-learning approaches to analyse different aspects of the Zhangzhung Nyengyü *tsakali* collection using the visual patterns in its digitised images. The findings from this research demonstrate the relevance of automated pattern analysis in this field of manuscript studies, and the potential for extending its applicability to other collections.

The handwriting style analysis using the handwriting analysis tool (HAT) revealed significant similarities among most cards, with notable exceptions suggesting contributions from different scribes. This insight can deepen our understanding of the production processes and scribes involved. The writing-support analysis with the line detection tool (LDT) identified variations in the papermaking techniques used, indicating multiple sources for the used paper in these cards. These results contribute to our knowledge of historical papermaking practices and trade in the region. Finally, the visual-pattern detector (VPD) successfully identified recurring visual elements, such as human-skull bowls, across the collection. This

capability allows for efficient retrieval and comparison of visual motifs within and across collections, offering new perspectives on cultural and ritual practices.

Overall, this research highlights the effectiveness of integrating machine-learning tools into manuscript analysis. These tools not only enhance our ability to detect and interpret patterns, but also open new avenues for cross-collection comparisons and historical insights. Future research can build on these findings by incorporating larger datasets and further refining the analytical techniques, thereby advancing our understanding of the historical and cultural contexts of these artefacts.

Agnieszka Helman-Ważny

Chapter 6: Multiscale Microscopic Analysis of the Paper and Fibres of the *Tsakali*

Abstract: In this chapter, both digital and optical microscopy were employed to study the raw material composition of *tsakali* paper. The fibre analysis reveals what the *tsakali* paper is made of, since the primary component of paper is the type of raw material used in its production. This ability to distinguish separate plant species in paper fibre is why fibre analysis, if and when applicable, is helpful in determining regional origin and sometimes in dating, especially when using a comparative study that entails overlapping typologies. Other aims were to learn about the relationship between the raw materials used and the properties of the resultant paper; and to deduce the origins of the paper by comparing the fibre identification results with local occurrences of the same plant. At the methodological level, this study also discusses the possibilities and limitations of different types of microscopes in the characterisation of both fibres and other components of paper, and how this may potentially contribute to the provenance study.

1 Microscopy and fibre analysis

Whenever digital or standard optical microscopes are used for fibre analysis, the aim of the procedure is exactly the same: to identify the fibres used in a manuscript's paper support on the basis of the morphological features of these fibres.¹ The crucial difference between these tools, however, in the context of heritage object analysis, is that digital microscopy allows for non-destructive testing, and optical microscopy requires that micro-samples be taken from the object to perform an analysis. Despite this fact, it is not so obvious when one method or tool should be selected over the other. In specific cases, optical microscopy may yet be more efficient in allowing for higher-precision identification. The samples to be observed under an optical microscope require preparation (boiling in water and

¹ Digital microscopy is not a microscope with a camera attached to it: it's an optical inspection system that is designed with the screen as the only output, so that the complete concept and construction of the microscope is different than a binocular-based microscope. Digital microscopes primarily offer speed and convenience, as with digital cameras. They can produce very high-quality images, limited only by the optical system of the particular tool.

then separating on the microscopic slide). This process aims to remove other components (than fibres) from the paper. Thus, on the one hand, after such preparation, it is possible to observe the fibres as whole cells, but on the other hand, it is no longer possible to document the paper's other components, as they are usually removed during sample preparation. It should be noted that most of the non-destructive spectroscopic techniques can provide information on paper components, not just on fibres (see Chapters 8 and 9 in this volume).² Thus, despite the development of many new methods in recent decades, optical microscopy is still the most useful for the botanical identification of plant tissue. In many cases, the optics and resolution of standard microscopes are better than digital ones, but this also depends on the specific type of microscope used.

The fibres belong to one of two general categories, natural and synthetic; then, depending on their origin, they can be classified as vegetable, animal or mineral.³ However, most of the fibres that were traditionally used for papermaking in Asia were of natural, vegetal (papermaking plants) or animal (silk, wool) origin.

The scientific protocol for analysing handmade paper through the identification of fibre materials by observing similarities in morphological features was first established by Julius Wiesner in the late nineteenth century.⁴ In the early stage, most microscopic analyses of paper fibres relied on a staining method to colour and distinguish the morphological features for identification. Staining is an auxiliary method, useful especially in cases of mixed fibre component paper. However, it is usually not sufficient for the identification of fibres on its own, due to the fact that the same colour can indicate rather large groups of possible fibre components. Furthermore, it requires a sample that can only be observed for about an hour after staining, and that becomes unsuitable for subsequent analysis. This is why staining is rarely used for the analysis of paper in heritage objects.

Digital microscopy allows for the study of paper in its original structure of interlaced fibres and all other possible components together. Furthermore, 3D digital microscopy offers fast 2D and 3D measurement, a larger depth of field and working distance than an optical microscope, as well as a very large range of magnification which can go from macro to micro, and many illumination techniques (including polarisation, differential interference contrast (DIC), transmission lighting and fluorescence).

² See Almogi et al. 2013–2014 [2015].

³ For a general overview of fibre categories and classification, see Herzog 1955; Ilvessalo-Pfäffli 1995; and Robertson, Roux and Wiggins 2018.

⁴ Wiesner 1892; Wiesner 1902; Wiesner 1903; Wiesner 1911.

The advantage of a digital microscope is that there is no need to interfere with the original object: the method is almost contactless. However, for this reason, it only allows us to see fragments of a fibre, and never the whole fibre as a cell. It is also challenging when the paper is coated with other substances, such as glue, primers or any other coating substances that limit the possibility of seeing anatomical features of the original plant cells. This makes identification much more difficult, and often impossible to conclude. Furthermore, there is no fixed protocol of observation, and it is challenging to trace the exact coordinates of the observed spot or area (depending on magnification). Thus, the measurements and observation of singular fibres may not always be possible to repeat in this case.

On the other hand, an obvious advantage of digital microscopy is that one can use digital microscopes in conditions that do not support the use of an optical microscope, for example in libraries or museums, allowing for work *in situ*. It is also more useful when many different recordings of a larger area are needed. In fact, the whole surface of the paper can be documented if needed, unlike with optical microscopy, which is performed on micro-samples taken from only one specific place. Thus, the unique flexibility of digital microscopy is an advantage, as the optical system can be attached to any support, enabling contact inspection of the paper surface (interaction of paper and ink) or non-contact inspection of an entire written artefact of any shape at a high resolution. This tool, therefore, is perfect for macroscopic analysis of the whole paper object, allowing for documenting and registering features observed at lower magnifications. This includes a wide range of features, such as surface texture, hue, interaction of paper and ink (or paints), presence of fillers, fibre distribution (if its visibility is not prevented by coatings), quality and impression of the screen (papermaking sieve print), the imprint of the material texture on which a paper has dried, the finishing process and remains of ancient repairs or conservation treatments.

This is why, though digital microscopy is preferable in general, it compromises the chances for precise identification. Thus, each method has its possibilities and limitations. One needs to know which methods to choose from to get the right type of information they may need. Considering all the facts discussed above, both methods complement each other, and are best used in combination. Furthermore, in both cases, the current state of microscopy offers much greater possibilities to observe specific anatomical features and indeed much better chances for successful identification.

2 Microscopic analysis of *tsakali* paper

Detailed analysis of these samples was performed at the Centre for the Study of Manuscript Cultures at Universität Hamburg. The paper samples were first immersed in

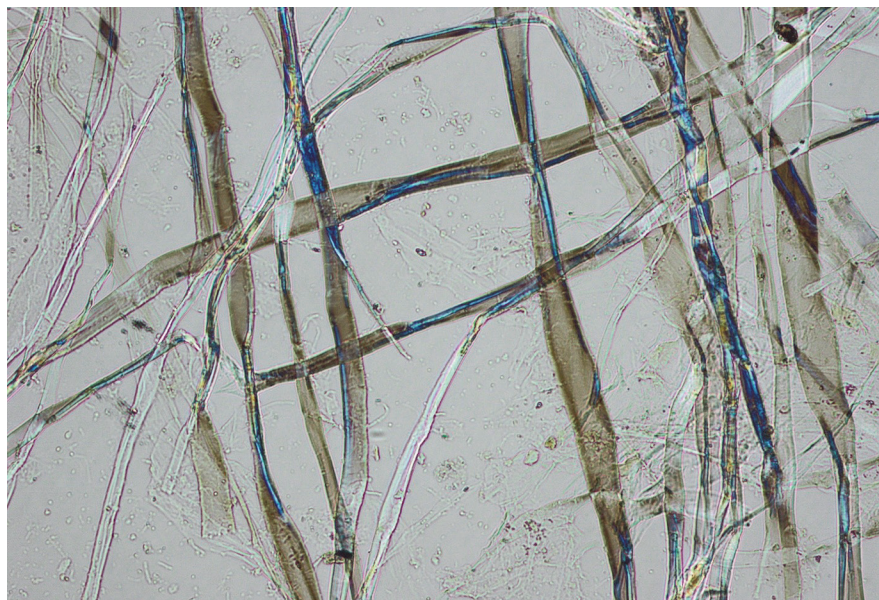
distilled water in a small beaker and boiled for ten to fifteen minutes. The water was decanted and the samples drained. About 0.2 g of paper pulp was placed on a microscopic slide and separated into a fine suspension of individual fibres. After water was dried, a drop of mounting solution was added and the microscope slide was closed with a coverslip. Then the slide, pressed between a metal plate and a magnet, was left until the mounting resin had dried. The fibres were then observed using an Olympus BX51 microscope with polarised light, and an Olympus UC30 digital camera that was connected to a computer and controlled by STREAM 2.4 PRO image analysis software, used for photographic acquisition. A range of magnification from 50× to 400× with both non-polarised and polarised light was used.

Attention was paid to the morphology of the fibres and other elements of the pulp, such as

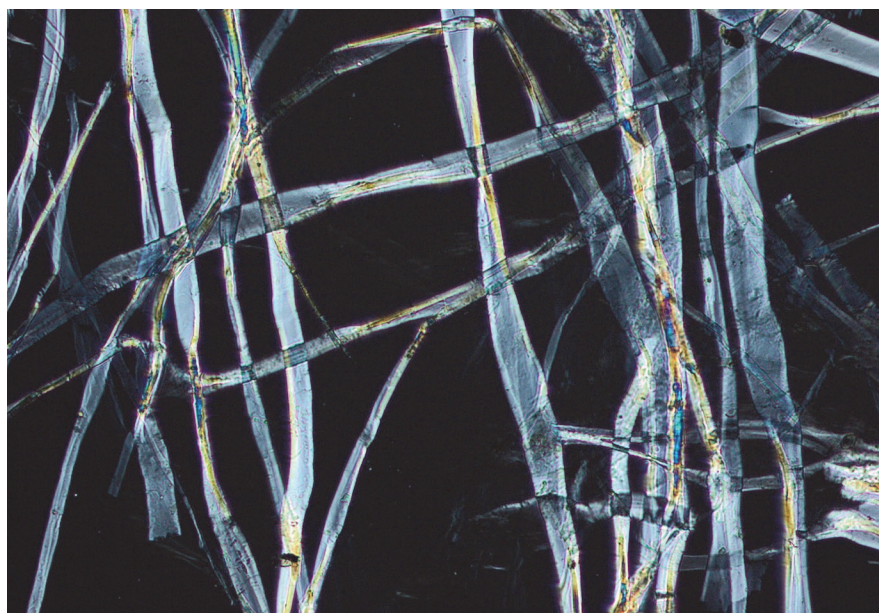
- the general shape of fibres and its flexibility (for this purpose, it was important to observe the entire fibre, not just parts of it);
- the regularity of the fibre structure (or lack thereof);
- the ratio of the lumen width to the cell wall of the fibres;
- the presence and characteristics of cross-markings and dislocations, as well as longitudinal striation;
- the shape of the natural fibre endings; and
- the colour that the fibres developed in the reagents.

The aim was to learn what plants were used to make the paper for the sixty-five cards, as well as how homogenous or mixed this paper was across the full set. A digital microscope (Dino-Lite AD413T-I2V) was first used to study the surface morphology and typology of the paper of all sixty-five *tsakali*. Then a Keyence VHX-5000 digital microscope, equipped with a VH-Z100UR objective, was used to observe the paper-surface characteristics and the interaction between paper and ink in these cards. Observation under both digital microscopes suggested that all sixty-five *tsakali* were made on the same type of paper, quite homogenous in its structure; however, the fibre identification has proved impossible. The cards were in fact made of a very similar type of paper, but, so far, only its smooth texture and fragments of fibres have been possible to characterise. Thus, aiming at the identification of the fibre material, thirteen *tsakali* were sampled for fibre analysis (see Table 1).⁵

⁵ The results are also in the appendix.



a



b

Figs 1a–b: *Stellera chamaejasme* fibres identified in Tsakali 8, observed under polarised light (parallel (a) and crossed (b) Nicol prisms) at a magnification of 200 $\times$.

As microscopic analysis showed, the paper of the *tsakali* under study, independently of its technological features (both woven and laid), is mostly homogeneous and made of *Stellera chamaejasme*. This plant belongs to the Thymelaeaceae family. Most of the fibres observed were flabby, ribbon-like in shape and with an impression of transparency: similar to cotton fibres, yet without the twisting typical of cotton, and shorter (see Figs 1a–b and 2). There were broad sections within the length of fibres that were typical of papermaking plants belonging to Thymelaeaceae family, such as *Daphne* sp. The wavy fibre walls and irregular lumens, however, clearly suggest that these are *Stellera* fibres, rather than *Daphne*. The fibre walls and lumen are much more irregular compared to *Daphne*. The lumen is often delineated by wavy fibre walls, which creates a very irregular space inside the fibre cell (see the arrows on Figs 1a–b). The colour that developed after treating one sample with Herzberg stain was olive-grey, the same as others from this family.⁶ The spiral vessels and minor woody fibres were present in the pulp of samples taken from Tsakali 1, 3 and 7. A singular fibre of silk was detected in Tsakali 2.

3 What can the results of the fibre analysis tell about the *tsakali* set?

Plants of the *Stellera chamaejasme* species thrive at high altitudes, and in some regions of Tibet, they have been used as the main raw material in papermaking (Fig. 2).⁷ *Stellera* is a small genus of less than ten species, belonging to the Thymelaeaceae family.⁸ It is also found growing in comparatively dry conditions in parts

⁶ The sample with Herzberg reagent was always prepared immediately before the analysis. First, a previously boiled sample was placed on a microscope slide, and a drop of Herzberg reagent was added. The sample was carefully dissected, and a coverslip gently placed on top so that no air bubbles formed.

⁷ Boesi and Helman-Ważny 2020.

⁸ Thymelaeaceae is a family of dicotyledonous flowering plants with 898 species in 50 genera. The phloem contains very strong fibres with a large quantity of hemicelluloses, which makes the bark of many Thymelaeaceae species very suitable for the manufacture of high-quality paper, such as that used for bank notes and writing supports. These fibres are long and narrow, and supportive cells provide tensile strength without limiting flexibility – further characteristics that render the bark a valuable material for papermaking. Yet another quality that makes Thymelaeaceae appropriate for papermaking is that most species are poisonous (while some are important medicinally); such paper can resist insect infestation longer than papers made of other plants and is therefore more durable and long-lasting.

of Central Asia, Bhutan, Nepal, Mongolia, Russia and China. It 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.

The plant is named *re lcag pa* in Tibetan, and as such is a well-known paper plant in many Tibetan cultural regions, such as Amdo, Kham and dBus gtsang, as well as in Nepalese high valleys like Dolpo and lower Mustang. Yet each region uses a local vernacular name for *Stellera*, such as *mgo re lcag re* in Lithang; *mgo nara* in Nepalese Dolpo; *mgo bo rol gdangs* in the lower Mustang District (Nepal); and *ra ma rwa co* in the Xining area (Qinghai Province, PRC).⁹ To my knowledge, *Stellera chamaejasme* is also known locally in Mustang as *sibri mentok* (*sibri* means ‘smelling of sweat’; *mentok* means ‘flower’).¹⁰

This plant was first described at the end of the nineteenth century.¹¹ It is a pest plant, which successfully competes with other species and quickly colonises degraded pasturelands. From the 1960s onwards, pasture over-exploitation has been a widespread phenomenon all over the Tibetan plateau and *Stellera* has been increasingly significant.¹² This implies that, when considering the amount of source material for papermaking that was available in the past, we cannot rely on the present abundance and distribution of this species. On the other hand, it is the only papermaking species that grows at over 3500 m above sea level. Thus, *tsakali* paper from *Stellera* roots must have been produced in the high Himalayan area, where practically nothing else grows, and by Tibetan craftsmen.

The altitude range of *Daphne* sp. reaches 3600 m above sea level, and *Stellera* sp. grows up to 4500 metres (*Daphne* plants need much more moisture than *Stellera*) (Figs 3a–b). Thus, these two species very rarely grow in the same habitat. Besides the different ecosystems in which these plants occur, their use is also conditioned by different technological requirements in the process of papermaking, such as (1) the hardship of collecting these roots growing deep in stones in the mountains, as well as (2) the extra steps of the papermaking process required to neutralise its poisonous qualities.

Identifying *Stellera* fibres in the paper of thirteen *tsakali* obviously confirms that they were created on Tibetan paper; we must additionally consider the dis-

⁹ Boesi 2016, 504.

¹⁰ Helman-Ważny and Ramble 2021.

¹¹ Kingdon-Ward 1934, 64; see also the sample of *Stellera chamaejasme* collected on 10 June 1922 in the *Herbarium of the L. H. Bailey Hortorium* at Cornell University, Department of Botany, College of Agriculture, Ithaca, NY.

¹² Boesi 2016, 507.

tribution of this plant suggesting that the *tsakali* were produced at the place located above 3600 m above sea level.

What are the implications for dating the *tsakali* production? From the perspective of manuscript studies, most of the early manuscripts from central and western Tibet – other than the Dunhuang manuscripts, which were written on rags or *Daphne* paper – were written on *Stellera* paper, or on paper in which *Stellera* is a predominant component.

Was *Stellera* used specifically for its properties? From the technological point of view, since manuscript paper must be processed before writing, it is possible to use a variety of fibres in its production, regardless of their individual properties and strengths. The only factor influencing the selection of the paper would have been the size of the manuscript. *Stellera* fibre alone is not stable enough for large formats (*Stellera* paper can easily bend or break). Smaller formats, like *tsakali*, were more easily produced on pure *Stellera* paper.

Besides paper made of *Daphne* fibre, Tibetans usually claim that paper made from *Stellera* sp. is the ‘original’ Tibetan paper. The reason is probably that Tibetans associate this type of paper exclusively with the ‘heart of their culture’, since the plant grows over 4000 m above sea level and is not mentioned anywhere else in the context of papermaking. There is no evidence so far that it was used in places other than the Tibetan plateau. The oldest samples of *Stellera* sp. in Tibetan manuscripts have been identified in a manuscript from central Tibet that dates to the tenth century and one from western Tibet that dates to the eleventh century.¹³ It should be noted, however, that there is no evidence of these plants in the Tibetan manuscripts found in Dunhuang. After the fifteenth century, this plant was more often used in addition to *Daphne* and *Edgeworthia*, possibly to add some softness to the *Daphne* paper and make it more suitable for printing.¹⁴

These *Stellera* root fibres alone create a very specific, soft type of paper that Tibetan papermakers later considered to be of lower quality than the bark paper made of *Daphne*, *Wikstroemia* and *Edgeworthia*. *Stellera* fibres are not considered as strong. The roots are especially difficult to harvest, which places a serious limitation on the quantity of paper that can be produced. They additionally require a longer time for processing. Thus, in general, they are only used in papermaking when no other sources are available. On the other hand, the poisonous properties of these plants make the paper resistant to damage caused by insects, meaning that it may ultimately be more durable than other types of paper.

¹³ Helman-Ważny 2016a.

¹⁴ Helman-Ważny 2016b.



Fig. 2: *Stellera* plant collected by paper makers in Dobe Shang; photo by Agnieszka Helman-Ważny during fieldwork in Tibet, 2013.



a



b

Figs 3a–b: (a) Digging out a *Stellera* plant in the skyid grong area of Tibet; (b) a *Stellera* plant growing in its natural habitat; photo by Agnieszka Helman-Ważny during fieldwork in Tibet, 2013.

Table 1: *Tsakali* paper.

Ordinal no.	Original <i>tsakali</i> no. and name	Type of paper (papermaking sieve print)	Fibre composition
1	0 Bum pa (vase)	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i>
2	1 Ye nyid kyis ston pa	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i> (spiral vessels and minor woody fibres present in the pulp)
3	2 Thug[s] [b]rtse'i ston pa	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i> (singular fibre of silk)
4	3 Cir yang sprul pa'i ston pa	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i> (spiral vessels and minor woody fibres present in the pulp)
5	4 Tshad med 'od Idan	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i> (short fibres, more damaged)
6	5 Yab 'Phrul gshen snang ldan	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i>
7	6 rGyud khungs kyi ston pa	Woven paper with many fibre bundles	<i>Stellera chamaejasme</i>
8	7 Yum Zang za rig btsun	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i> (spiral vessels and minor woody fibres present in the pulp)
9	8 Sras 'Chi med gtsug phud	Woven paper with many fibre bundles	<i>Stellera chamaejasme</i>
10	9 gShen gSang ba 'dus pa	Woven paper without fibre bundles (cloudy fibre distribution)	<i>Stellera chamaejasme</i>
12	25 De sras dGe 'phan	Laid paper	<i>Stellera chamaejasme</i>
13	A Zhing lnga gtso' bo	Woven paper	<i>Stellera chamaejasme</i>

Sylvio Haas, Agnieszka Helman-Ważny

Chapter 7: The Application of Small- and Wide-angle X-ray Scattering to the Study of the Paper Support and Pigment Distribution

Abstract: This chapter discusses the capabilities and limitations of X-ray-based scattering techniques to study the Zhangzhung Nyengyü *tsakali* collection. Small-angle X-ray scattering (SAXS) was used to study the orientation distribution of the cellulose fibrils of the paper support. Wide-angle X-ray scattering (WAXS), which includes X-ray diffraction, was used to map the mineral phase of the pigment in the paint layer. Importantly, the X-ray dose applied was minimised so that no structural changes were observed, making the study explicitly non-destructive to the object.

1 The objective of the *tsakali* analysis utilising small- and wide-angle X-ray scattering

In the past, the X-ray study of heritage objects has been conducted exclusively through the use of X-ray fluorescence (XRF) or X-ray diffraction (XRD) techniques. The principal objective of these studies was the classification of the paint pigments that were employed. In addition to XRF and XRD, other X-ray techniques are now available for the study of objects from a material perspective. In the present study on the *tsakali*, the objective was to explore the potential of using small- and wide-angle X-ray scattering (SAXS/WAXS)¹ to gain insight into the *tsakali*'s materials. Fig. 1 illustrates the information that can be obtained through SAXS and WAXS investigations. The SAXS pattern provides information about the cellulose fibril structure, including the diameter of the fibrils, the distribution of their lengths, and the orientation of their axes. This makes it an ideal tool for investigating the paper support of *tsakali*. The WAXS pattern includes information about amorphous phases such as water, organic components, binders, etc. and information about crystalline material phases. The latter is based on X-ray diffraction.

1 Glatter and Kratky (eds) 1982; Guinier and Fournet (eds) 1955.

It should be noted that a WAXS experiment includes XRD, but not vice versa. In this chapter, the term WAXS is employed.

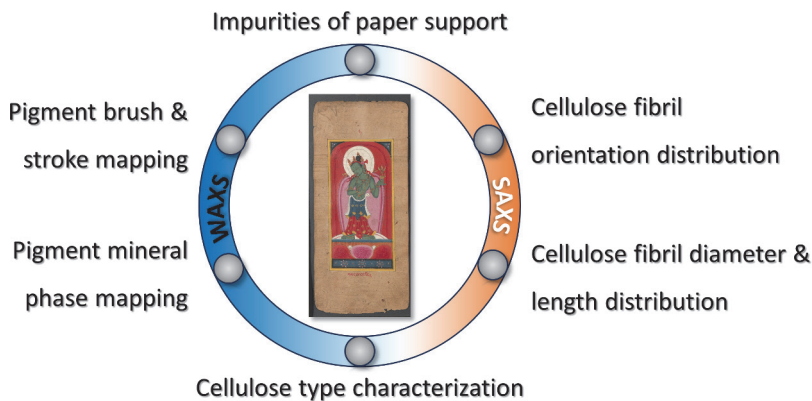


Fig. 1: Overview of the topics addressed by non-destructive X-ray scattering techniques grouped by the SAXS or WAXS method, respectively.

It is of particular importance to note that the focus here is on explicitly non-destructive kinds of measurements. In many cases, this approach has the disadvantage of yielding only low-resolution structural information, as opposed to high-resolution structures of materials. In any case, this chapter demonstrates the considerable information that can be obtained even with low-resolution measurements and without causing damage to the objects under investigation.

2 Basics of small- and wide-angle X-ray scattering

2.1 Principle of the technique

The fundamental principle underlying a SAXS/WAXS experiment is illustrated in Fig. 2. A monochromatic X-ray beam is collimated and directed in transmission mode towards the object. The X-rays are scattered by the electron density of the object. A two-dimensional area-sensitive photon-counting X-ray detector, situated at a considerable distance from the sample, records the scattered photons as a function of the scattering angle $2\theta_{\text{SAXS}}$, azimuthal angle χ and objects translation coordinates ω , y , z . The scattering angle $2\theta_{\text{SAXS}}$ can be expressed in terms of the X-ray energy-independent scattering vector q_{SAXS} . The scattering vector q_{SAXS} enables

an approximation of the dimension of structures at $D \approx 2\pi / q_{\text{SAXS}}$. The SAXS detector is typically situated between 2 m and 12 m behind the sample, contingent on the anticipated structural dimensions. The WAXS patterns are collected in parallel with a 2D area-sensitive photon-counting detector situated at a considerably closer distance behind the sample (0.2 m–0.4 m). A scattering angle $2\theta_{\text{SAXS}}$ range of 2° to 50° can be covered without moving the detector. The sample can be mapped by translating it horizontally y , vertically z and rotated around the vertical axis ω .

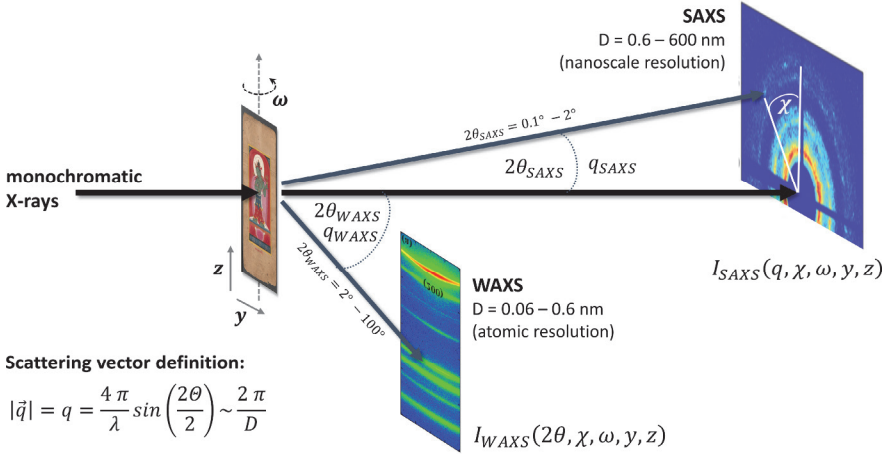


Fig. 2: Sketch of the principle of small- and wide-angle X-ray scattering mapping experiment. The 2D resolved photon-counting detectors are placed behind the sample at different distances at the same time.

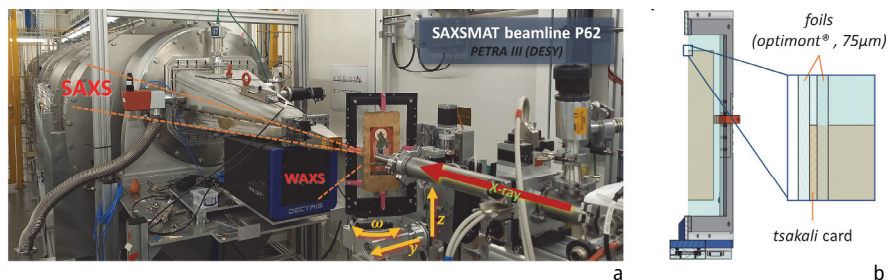
2.2 Experimental setup and sample handling

The combined SAXS/WAXS mapping experiment was conducted at the SAXSMAT beamline P62 at the synchrotron PETRA III at DESY, Hamburg, Germany.² This beamline has been designed to facilitate the conduct of SAXS/WAXS imaging experiments, employing on-the-fly data acquisition strategies to minimise acquisition overhead time. Moreover, the X-ray energy can be modified from 3.5 keV to 35.0 keV, enabling the X-ray transmission to be adjusted to approximately 30 per cent, which is the optimal value for SAXS. The capability of the beamline permits the investigation of objects of varying thicknesses, spanning a range from a few micrometres to several millimetres depending on the object composition and density.

² Haas et al. 2023.

Fig. 3a shows a photograph of the beamline with Tsakali D mounted on the translation and rotation stages with a special holder. A 3D CAD sketch of the 3D-printed frame of the holder is provided for reference (Fig. 3b). The *tsakali* is positioned between two foils that are nearly X-ray transparent (*optimont*®, Bleher Folientechnik GmbH, each 75 μm thin). A distance of approximately 20 mm is maintained between the PLA-printed frame and the object on either side, allowing for the clamping of the two foils without contact with the object itself. This method allows for the application of minimal clamping forces to the *tsakali* object while maintaining its fixed position within the frame.

The SAXSMAT beamline allows the installation of larger chambers for more complex object handling if required, such as temperature and/or humidity control with a large scanning range of the object. Moreover, the range of applicable methods may be extended to include XRF, Raman, FTIR and so forth.



Figs 3a–b: (a) Photograph of the SAXSMAT beamline P62 with the mounted *tsakali*. The degrees of freedom of movement are indicated. (b) Cross-section view of the sample holder highlighting the clamping of the *tsakali* between two thin foils that are nearly transparent under X-ray.

A significant consideration in X-ray investigations, particularly those conducted at synchrotrons with high brilliance, is the potential for radiation-induced damage to heritage objects. This issue has been addressed on numerous occasions in various X-ray scattering experiments, and the prevailing conclusion is that there is no universally applicable method for estimating the X-ray dose an object can tolerate before damage occurs. The deterioration of historical paper induced by synchrotron X-ray techniques was recently investigated by Alice Gimat, Sebastian Schöder, Mathieu Thoury and Anne-Laurence Dupont,³ who demonstrated that a dose exceeding 20 Gy can already induce radiation damage. At even higher dose

³ Gimat et al. 2022.

rates, alternative mechanisms may become active. In order to avoid or, at the very least, minimise the risk of radiation damage, it is recommended that a test experiment be conducted on a single spot of the object prior to the final investigation. Ideally, the location should be of lesser importance. To conduct a radiation test, it is necessary to collect a time series of acquisitions with continuous X-ray radiation on the sample. From the time-dependent evolution of the scattering intensities, it is possible to ascertain the maximum exposure time. The maximum exposure time is defined as the point at which the scattering profile begins to exhibit a change. Based on the determined maximum exposure time, the final mapping experiment can be planned in a way that ensures the object is not exposed for a longer period of time. It is recommended that a safety factor of at least 2 to 3 be included. The total X-ray dose per point for the *tsakali* was below 20 Gy. Nevertheless, the possibility of long-term effects cannot be discounted at this stage. It is crucial to emphasise that the estimated maximum dose is the X-ray dose per area. Focusing the X-ray beam will increase the dose per area, resulting in a significantly shorter maximum exposure time for a focused X-ray beam compared to a larger, unfocused X-ray beam on the object. Therefore, the spatial resolution is somehow limited for non-destructive experiments, resulting in low-resolution data.

2.3 Mineral phase determination using WAXS/XRD

The determination of the mineral phase can be achieved through the analysis of the X-ray diffraction (XRD) signal of the crystalline phases, which is included in the recorded WAXS patterns. In the past, several tools have been developed for determining phases based on measured XRD intensity profiles as a function of scattering angle $2\theta_{\text{SAXS}}$, utilising the reported crystal structures in the Crystallographic Open Database (COD).⁴

An alternative approach is to solve the crystal structure via Rietveld refinement, as referenced.⁵ A number of software packages are available to facilitate Rietveld refinement.⁶ This technique is highly effective, but it does require high-resolution intensity profiles and that the powder average condition is fulfilled. This necessitates the presence of a considerable number of diffracting crystals within the X-ray beam. In the absence of these conditions, the diffraction peak ring on the 2D detector will appear as a series of isolated spots rather than a con-

⁴ De Nolf, Vanmeert and Janssens 2014.

⁵ Young (ed.) 2002.

⁶ Rodríguez-Carvajal 1993; Lutterotti, Matthies and Wenk 1999; Toby and von Dreele 2013.

tinuous and smooth intensity distribution. The recorded diffraction peaks of the paint pigments on the *tsakali* exhibited both spotty and smooth rings, rendering the application of Rietveld refinement infeasible.

Another option is to undertake a Pawley refinement.⁷ This technique optimises the diffraction peak positions based on the crystal structure and atom positions within the crystal. However, it does not refine the amplitude according to the Rietveld refinement theory.

In order to implement either of the proposed refinement options, it is first necessary to have some knowledge of the expected crystalline phases present in the object. In many instances, the optimisation process fails to converge when peaks of unknown phases are present in the spectra. In the case of the *tsakali*, this proved to be the issue, given that the paper backing contains a multitude of unknown phases of impurities. The presence of these impurity phases is not homogeneous throughout the entirety of the card, which renders the automated processing of the mapped WAXS signal unfeasible. It is anticipated that the utilisation of artificial intelligence (AI) tools will allow for overcoming this obstacle in the future.

Should destructive measurements of the object of interest be feasible, a small fragment of the pigment layer could be extracted from the object and subjected to a high-resolution powder diffraction experiment. This methodology has been previously employed in the analysis of the renowned painting *The Night Watch* by Rembrandt.⁸

Because this study focuses explicitly on non-destructive measurements, extracting a small fragment was not an option. Therefore, a modified version of the Pawley technique was developed for this project. Fig. 4 shows a flow chart of the main WAXS data processing steps followed to retrieve the mineral phase maps of the paint layer of the *tsakali*. The first step is recording WAXS pattern $I(px, py, \omega, y, z)$ as a function of the detector pixel coordinate px, py and the sample translation y, z . For the pigment analysis, the sample rotation $\omega = 0^\circ$ is sufficient. The next step is the coordinate transformation to record the intensity as a function of scattering angle 2θ and azimuthal angle χ . Step 3 is the summation of the intensity over all azimuthal angles χ , because for the pigment phase analysis, orientation of the crystals is not important. The result of this step is 1D diffraction profiles $I(2\theta, y, z)$ as a function of scattering angle 2θ for each card coordinate (y, z) . The next step involves a peak find algorithm to generate a list of each diffraction peak in the 1D diffraction profiles. This step generates lists of the peak centres, the full-width half

⁷ Pawley 1981.

⁸ Broers et al. 2023.

maxima and the amplitudes of the peaks. Step 5 involves the selection of a certain mineral phase from the COD database: basically, the diffraction peak positions of the assumed phase. In the next step, an amplitude map is generated by comparing the selected peak position of a certain reflex with the list of peak positions found for the measured spectra. If the selected peak was found in step 4, the amplitude is taken for the current coordinate (y, z); otherwise, the amplitude for the coordinate (y, z) is zero. Step 6 will be done for many different (hkl) diffraction peaks. The Miller indices (hkl) represent a set of three numbers that indicate the orientation of a set of parallel planes of atoms in a crystal. The atoms are connected by virtual lines, resulting in the formation of the crystal lattice. This lattice can be divided into a number of repeating identical blocks, called unit cells. The intersecting edges of one of the unit cells define a set of crystallographic axes, and the Miller indices are determined by the intersection of the plane with these axes. The reciprocals of these intercepts are computed and fractions cleared to yield the three Miller indices (hkl). The last step (7) is the comparison of the amplitude maps generated for the different (hkl) values. If the maps are similar in bearing a certain error, the phase has been identified; otherwise, a different mineral has to be selected in step 5.

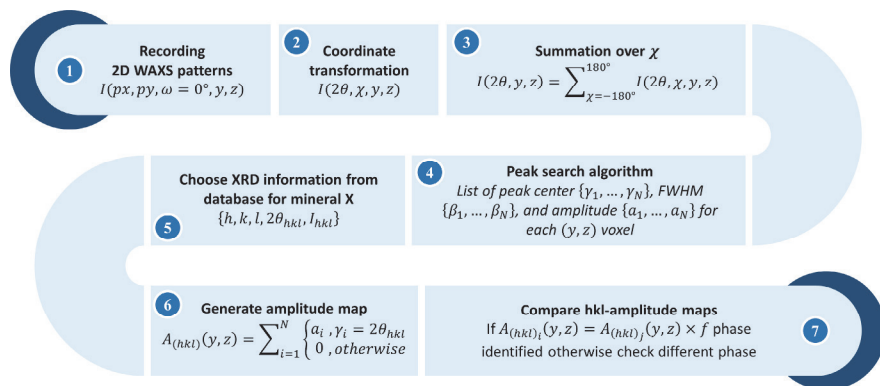


Fig. 4: Flow chart of the WAXS data processing pipeline, starting from the measurement until the final determined mineral phase map.

The advantage of the approach developed is that it can be automated to process all voxel coordinates (y, z), and the impact on the amplitude maps of the unknown phases is much less compared to the refinement techniques. During the *tsakali* study, it turned out that even overlapping diffraction peaks – as were observed

for the cards under study – do not pose a significant problem in identifying the proper mineral phase.

2.4 Nano-object analysis using SAXS

The SAXS patterns can be analysed in many ways depending on the information of interest. The analyses can be classified into model-dependent and model-independent approaches. The model-dependent approaches assume pre-knowledge about the nano-structure of the investigated object; in particular, the shape of the nano-objects must be known, otherwise the model employed to fit the 1D scattering profiles will be wrong. This kind of analysis has been applied successfully for many sample systems, specifically in the field of *in situ* and *operando* catalysis research. This approach allows for the determination of particle shape and size distribution in the range of 1 nm to 1000 nm, particle interaction potentials and, if present, particle self-assembly phenomena. In the past, several tools – such as SasView 4.2.0 software⁹ or SASFIT¹⁰ – were developed for easy modelling of 1D scattering patterns based on a variety of models (different shapes of particles, different size distributions, different interaction potentials). An overview of the underlying equations of the structural models is given in several publications.¹¹

Protein research utilising SAXS uses a Monte Carlo-based approach to retrieve the shape and size of the protein nano-particle, assuming a mono-disperse particle system.¹² The European Molecular Biology Laboratory (EMBL) has developed the ATSAS package,¹³ a comprehensive analysis package, to deal with this kind of analysis. The same approach has been applied to metallic nano-particle systems because nano-particle systems can now be built with almost mono-disperse size.¹⁴

The analysis of the *tsakali* follows the model-independent approaches, because both the paper support, as well as the paint layer that is in contact with the cellulose structure, has a complex nano-structure, and not much knowledge is available on the nanometre level. Fig. 5 shows the flow chart of the SAXS processing pipeline. The first two steps are identical to the WAXS processing: basically, recording the SAXS patterns and performing the coordinate transformation to obtain the SAXS scattering profiles as a function of the scattering vector q , azi-

⁹ <<http://www.sasview.org>> (accessed on 29 July 2025).

¹⁰ Breßler, Kohlbrecher and Thünemann 2015.

¹¹ Glatter and Kratky (eds) 1982; Pedersen 1997.

¹² Svergun 1999.

¹³ Manalastas-Cantos et al. 2021.

¹⁴ Burian et al. 2015.

muthal angle χ and the object location ω , y and z . In the next step, either the shape and size of the nano-structure building blocks are determined (step 3), or orientation analysis can be applied in the case of anisotropic nano-structures (steps 4–6).

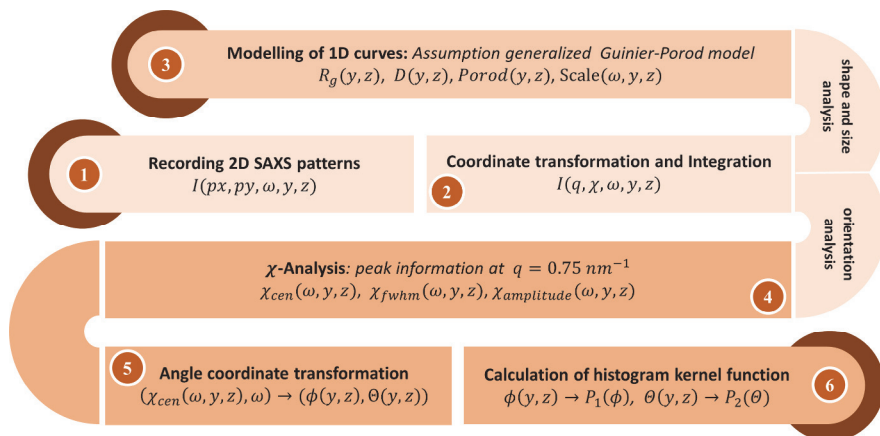


Fig. 5: Flow chart of the SAXS data processing pipeline, starting from the measurement until the final orientation and/or shape-size analyses.

The shape and size analysis (step 3) involves fitting the 1D scattering profiles with an empirical model that can be used to determine the size and dimensionality of scattering objects, including asymmetric objects such as plates, rods and ellipsoids. The generalised Guinier-Porod model is described in a publication by Boualem Hammouda.¹⁵ For each voxel (y, z) of the mapped *tsakali*, the radius of gyration of the object $R_g(y, z)$, the dimensionality of the object $D(y, z)$ and the Porod exponent $Porod(y, z)$ will be determined, as well as a scaling factor $Scale(\omega, y, z)$. The radius of gyration R_g is related to the size of the nano-object. The dimensionality parameter D represents the shape of the object and is 3 for spherical objects, 2 for rods and 1 for plate-like objects. The Porod exponent $Porod$ describes the local interface roughness of the nano-objects. A value of 4 indicates a flat surface for the objects; a value between 3 and 4 indicates surface fractals, and a value smaller than 3 indicates a volume fractal-like surface structure for the nano-object. The generalised Guinier-Porod model is extremely powerful because it does not assume any information about the particle shape or size, but delivers

¹⁵ Hammouda 2010.

useful information about the objects: in the case of the *tsakali*, the determined parameters describing the cellulose nanofibril structure of the paper support.

The orientation analysis (steps 4–6) involves the analysis of the azimuthal angle χ dependency of the scattering intensity. In step 4, the oscillation of the intensity at a certain q value will be analysed as a function of χ . The result will be the peak position χ_{cen} , peak full-width half maxima χ_{fwhm} and the peak amplitude $\chi_{amplitude}$ as a function of the object translation coordinates ω , y and z . The obtained peak position $\chi_{cen}(\omega, y, z)$ as a function of the sample rotation ω can be transformed into the real orientation angles $\phi(y, z)$ and $\theta(y, z)$ of the nano-object (step 5). The transformation involves solving a system of equations.¹⁶ In the case of the *tsakali* investigations, the two sample rotations $\omega = 22.5^\circ$ and $\omega = 45.0^\circ$ have been used to solve the equations to obtain the orientation angles ϕ and θ . In the last step (6), the obtained orientation angle maps $\phi(y, z)$ and $\theta(y, z)$ as a function of y and z were statistically analysed by calculating the histogram kernel functions $P_1(\phi)$ and $P_2(\theta)$, respectively. A kernel distribution represents the probability density function (PDF) of a random variable in a non-parametric manner.¹⁷ Its use is appropriate when a parametric distribution is unable to adequately describe the data, or when it is preferable to avoid making assumptions about the distribution of the data.

3 Pigment analysis of *tsakali* based on X-ray diffraction

This section summarises the results of the study of the colour palette of the *tsakali* based on the evaluation of the WAXS mapping. The pigment analysis has been carried out on Tsakali 0 and Tsakali D. Here, only the results of Tsakali D are shown, but the results of Tsakali 0 are identical. The analysis was completed as described above. The amplitude maps of many different mineral phases for several diffraction reflexes were determined and finally compared to each other and the real object. The following mineral phases were tested for the different colours:

- **Yellow:** Gold (Au), orpiment (As_2S_3), realgar ($\alpha\text{-As}_4\text{S}_4$), yellow ochre (mixture of iron-containing minerals)
- **Green:** malachite ($\text{CuCO}_3\text{Cu(OH)}_2$), azurite ($2\text{CuCO}_3\text{Cu(OH)}_2$)
- **Red:** cinnabar (HgS), red lead (Pb_3O_4), red ochre ($\alpha\text{-Fe}_2\text{O}_3$)
- **White:** kaolinite ($\text{Al}_4[(\text{OH})_8|\text{Si}_4\text{O}_{10}]$), limestone (CaCO_3), lead white ($2\text{PbCO}_3\text{Pb(OH)}_2$)

¹⁶ Georgiadis et al. 2015.

¹⁷ Bowman and Azzalini 1997.

- **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 ($\text{Fe}_4[\text{Fe}(\text{CN})_6]_3 \cdot x\text{H}_2\text{O}$)

Fig. 6 shows the amplitude maps for one selected diffraction reflex of the determined mineral phase for each different colour.

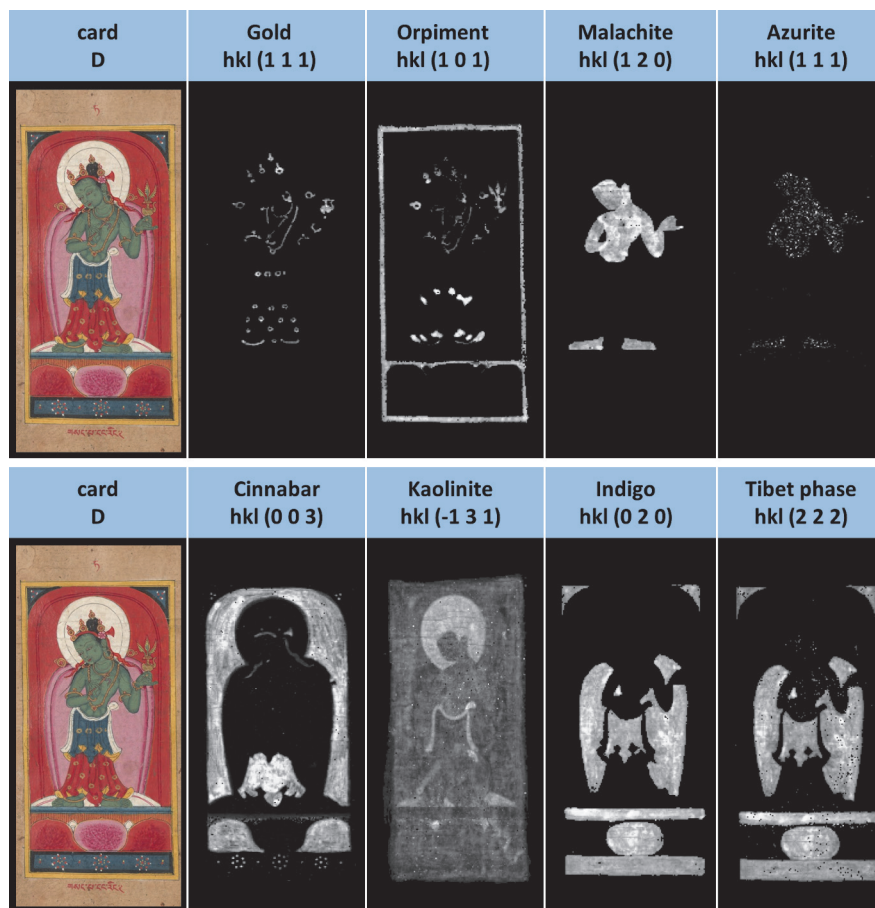


Fig. 6: Overview of the pigment mineral phase maps determined using X-ray diffraction. One selected diffraction reflection is shown as an example for each colour. A lighter colour indicates a higher intensity, which in turn corresponds to a higher concentration of the mineral phase.

Gold has been found in the paint layer of the *tsakali*. Gold (*gser*) is universally associated with wealth and beauty. It was widely used for artistic purposes in

Tibet, in various forms including gold powder (*gser rdul*), gold leaf (*gser shog*), and mercury-gold amalgam.¹⁸ Tibet was also known as a country with significant gold deposits, with mines in proximity to Tholing that were actively exploited, under a royal edict, as early as the eleventh century by a hundred miners and their families.¹⁹ In painting, gold was typically used to provide highlights or to articulate details, often over the parts first executed in yellow. The pigment determined for yellow is orpiment, as one can see on the amplitude map. The region that contains gold also contains orpiment, which means that some important details were first painted in yellow using orpiment, and later overpainted with gold to highlight them.

The green pigment mineral was found to be a mixture of malachite and azurite, as one can see on both amplitude maps. Here, the malachite phase exhibits a smooth closed area where the green colour is present; on the other hand, the azurite mineral phase present in the same area looks much spottier, indicating the occurrence of only a few larger grains rather than a closed package of smaller mineral grains. In any case, both minerals were identified in the green-coloured areas. The occurrence of both phases matches our expectations, because in mines, both phases are typically present at the same locations. After all, azurite can degrade over time to malachite, as happened in the mines.

The red pigment phase was identified as cinnabar (Tib. *cog la ma*) or vermilion (Tib. *mtshal*). The amplitude map of cinnabar nicely represents the areas that are painted in red. Although the red region appears homogeneous in the photograph, the WAXS amplitude map of cinnabar reveals intensity fluctuations associated with varying layer thicknesses resulting from the painting process. The direction of the brushstrokes used in the painting process can be discerned. The red area appears to have been painted with brushstrokes from top to bottom. The width of some brush strokes is as little as 1 mm. The mapping of the pigment phase enables the formulation of inferences pertaining to the painting process, particularly regarding the brushwork employed. This option may be used for the authentication of paintings, provided that the brushwork is either known or has been subjected to prior analysis. This could facilitate the future recognition of forgeries exhibiting a distinctive brushstroke.

The investigation of the white colour areas revealed that the white pigment is a kaolinite mineral, and it is present not only in the visible white areas (around the head), but also throughout the entire paint layer. The areas that are visible as white paint exhibit a greater quantity of the kaolinite phase. It can be surmised

¹⁸ Jackson and Jackson 1984.

¹⁹ Pritzker 2008; Heller 2013; Davidson 2005.

that either the craftsman has first prepared the rectangular area with a thin white layer to facilitate the binding of the colour layers and enhance their lustre, or the colour phases have been mixed with kaolinite prior to painting. The latter hypothesis is untenable, as the amplitude of the white phase content should vary across different colour areas, due to potential differences in mixing ratios or layer thicknesses. However, the kaolinite phase appears to be homogeneous across the entire surface, apart from the white areas. Consequently, it can be concluded that the painted area was initially executed in white, and subsequently overpainted with the final painting layer.

The most intriguing discovery is the identification of the blue pigment phase. It has been determined that the pigment in question is a mixture of indigo and a previously undiscovered pigment, designated as the Tibet phase. This mixed pigment is present in both the blue and pink painted areas. The ratio of Fe and As in the Tibet phase of the pigment determines the visual colour. While a detailed crystal structure of the pigment phase could not be resolved due to the low-resolution measurements, the presence of this new phase could be concluded even from low-resolution non-destructive measurements.

The analysis of pigments using X-ray diffraction patterns is a supplementary method to the classical techniques employed in pigment analysis. A direct comparison can be made with Raman spectroscopy, which also determines mineral phases directly. The crystal structure obtained by X-ray diffraction can be employed to theoretically calculate the Raman spectra of the mineral phase, which can then be compared to Raman spectroscopy examinations, as demonstrated in Chapter 9. The mineral phase maps can be compared to X-ray fluorescence maps, which provide information on the distribution of elements and must align with the composition of the identified minerals.

The size and shape analysis of the SAXS patterns collected concurrently provides supplementary data regarding the paint layer. The radius of gyration map (see Fig. 7) generated for Tsakali D exhibits a radius between 80 and 100 nm. This radius is correlated with the dimension of the cellulose fibrils. The radius of gyration is smallest in the unpainted areas of the card, while the painted areas exhibit a larger radius. The significance of this increased radius of gyration remains to be elucidated. One potential explanation is that the fibrils undergo swelling when in contact with water, which subsequently disperses the kaolinite and the colourants. An alternative hypothesis is that the kaolinite phase is attached to the fibrils by forming a shell around the cylindrical fibrils. However, further research is required to elucidate this phenomenon. In particular, studies on reference systems are essential to gain a comprehensive understanding of the structural changes observed by SAXS. Despite the lack of detailed understanding of these

changes, the simplified SAXS analysis clearly indicates that structural changes occur at the nanometre level.

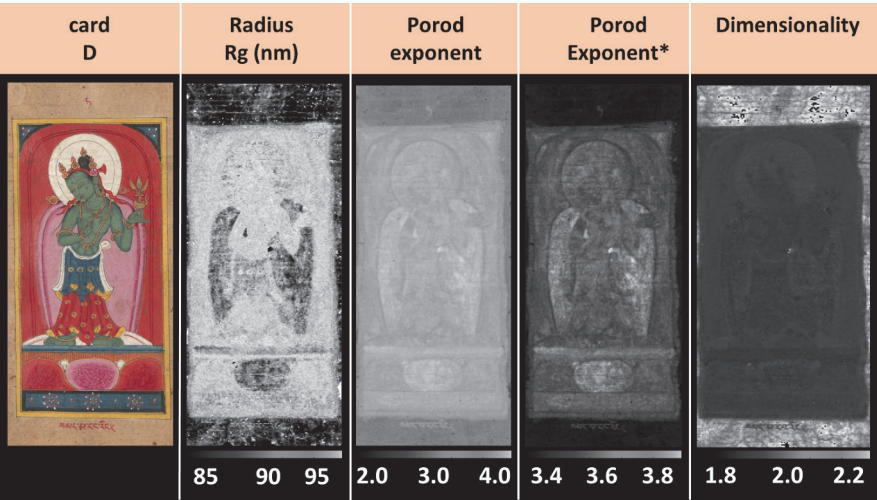


Fig. 7: Results from the shape and size analysis of the SAXS intensity maps. The following parameters were determined: radius of gyration, dimensionality and Porod parameter. In this panel, the colour scale is limited to highlight the differences in the Porod exponent for the different colours.

As illustrated in Fig. 7, the Porod exponent map depicts the variations in value. This suggests that the local interface roughness may vary between the different coloured areas. It is noteworthy that the distinct colour areas are discernible in the Porod exponent map. Once more, the blue and pink areas exhibit the most disparate values (nearly 3.8) in comparison to all the other coloured regions.

A visual representation of the dimensionality parameter map, illustrated in Fig. 7, depicts values ranging from 1.8 to 2.2. The unpainted area exhibits a dimensionality factor between 2.0 and 2.2, while the painted area displays a value more closely aligned with 1.8 to 2.0. The dimensionality parameter of the unpainted area effectively illustrates the heterogeneity of the cellulose structure of the paper support.

The nano-structure parameters may be employed in future research to potentially classify handmade paper based on the nano-structure parameter. The utilisation of nano-structure parameters as a reference point for authentication and potential provenance studies represents a promising avenue for the future development of this technique. The advantage of utilising a nano-structure parameter is that it is difficult to replicate unless you already know what structure you are

trying to achieve. Even with this knowledge, it is not a simple task to generate the correct nano-structure.

4 Grouping the *tsakali* based on the cellulose fibril orientation analysed by SAXS

Based on the microscopic investigations of the fibres²⁰ as well as the ¹⁴C dating,²¹ the question arises as to whether the collection of sixty-five cards is composed of smaller sub-collections. Within the SAXS analysis of the *tsakali* collection, the idea came up to use the orientation of the cellulose fibrils of the paper support as a parameter to group the cards. It is believed that the cellulose fibril orientation is strongly correlated with the handmade papermaking process, and therefore a classification should be possible if the orientation of the fibrils can be determined accurately. This approach has not been applied for many objects so far; therefore, it is a highly experimental method of development. Similar work has recently been carried out on a set of reference paper samples in combination with other techniques to validate the orientation findings.²² However, more studies are necessary to fully show the potential of this kind of classifying approach with orientation analysis using SAXS.

All sixty-five cards have undergone raster scanning with the X-ray beam. An area of 10 mm × 10 mm below the paint area was scanned with a step size of 1 mm and a relatively large beam size of 250 µm × 250 µm. This allowed the X-ray dose to be distributed over a large area, thereby reducing the risk of radiation damage. The raster scan was conducted at two sample rotations with respect to the incoming beam, at angles $\omega = 22.5^\circ$ and $\omega = 45.0^\circ$, respectively. The determination of the fibril orientation angles has been done as described previously. In Fig. 8b, the definition of the orientation angles ϕ and θ with respect to the paper surface is depicted.

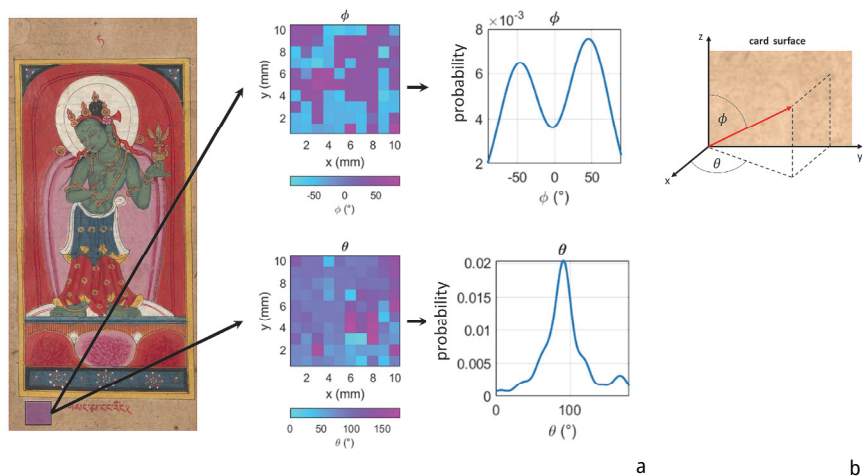
Fig. 8a illustrates the outcome of the distinct processing stages for Tsakali D. At each raster point (x, y), the primary orientation angle ϕ and θ has been determined based on the SAXS pattern assessment. The orientation angle maps were employed to ascertain the histogram kernel distributions, designated as $P_1(\phi)$ and $P_2(\theta)$, respectively. These distributions represent the probability of finding a specific orientation

²⁰ Performed by Agnieszka Helman-Wazny; see Chapter 6.

²¹ See Chapter 10.

²² Grzelec, Haas and Helman-Wazny 2025.

angle within the raster-scanned area of the paper support. The aforementioned histogram kernel distributions were determined for all sixty-five *tsakali*.



Figs 8a–b: (a) Overview of the orientation analysis shown as an example for Tsakali D. The obtained probability kernel functions will be used for grouping the *tsakali* based on the orientation of cellulose fibrils. (b) Coordinate system.

A comprehensive account of all orientation distributions will be presented in a forthcoming publication. The majority of the ϕ distributions exhibit two principal peaks at approximately -48° and 42° . In contrast, the θ distributions predominantly exhibit a single prominent peak at approximately 90° . Fig. 9 depicts all kernel distributions and groups them according to the similarity of the ϕ distribution. Group A comprises the *tsakali* that display comparatively weaker, randomly distributed peaks in the ϕ distribution kernel, apart from the two main peaks. Group B comprises the *tsakali* that exhibit only the two main peaks, situated at approximately -50° and 50° . It is noteworthy that the full-width at half-maximum of the ϕ peaks is considerably broader for the Group B cards in comparison to the Group A cards.

A more detailed examination of the θ kernel distributions reveals a comparable pattern. The Group B cards predominantly display a primary sharp peak in proximity to 90° . Group A cards demonstrate a considerably broader range of variation for the primary peak (80° – 120°) and a greater number of satellite, albeit weaker, peaks distributed randomly across the entire angular range of 0° to 180° .

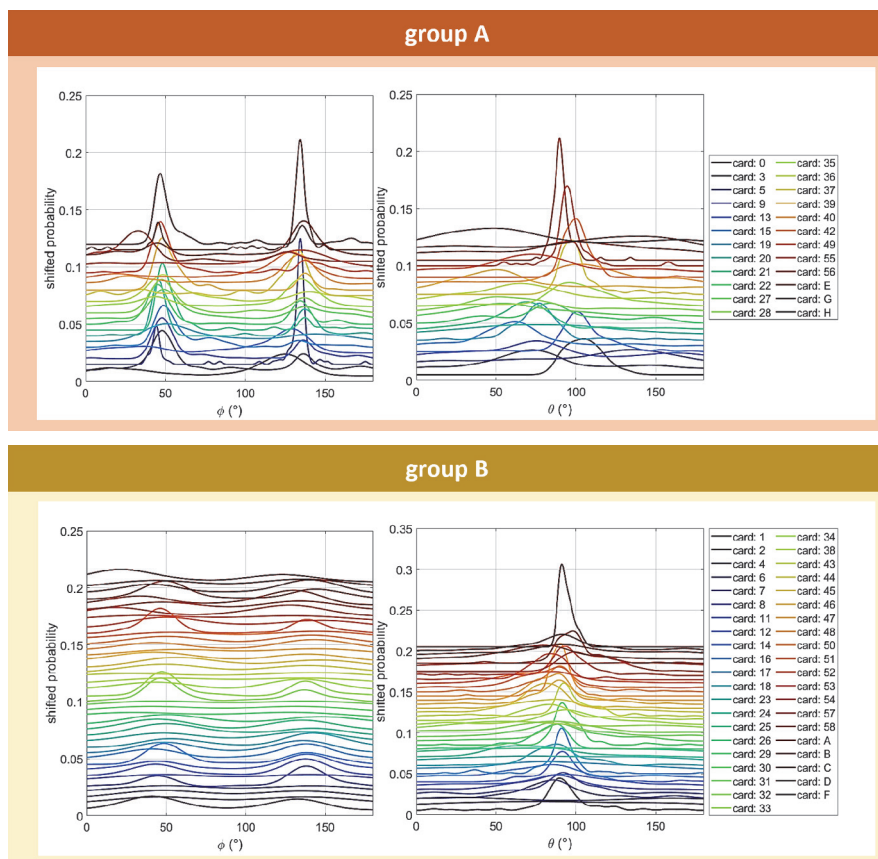


Fig. 9: Grouping of the *tsakali* into subgroups A and B based on the cellulose fibril orientation angle distributions determined by SAXS. The grouping is based on the similarity of the kernel distributions.

The ^{14}C dating yielded disparate ages for Tsakali 0 and Tsakali D, which aligns with the grouping based on the fibril orientation angles. Tsakali 0 is assigned to Group A, while Tsakali D is assigned to Group B.

The differences observed in the orientation distributions are a consequence of the papermaking process. A comprehensive analysis is beyond the scope of this chapter, but will be presented in a subsequent publication based on studies of reference samples produced under controlled conditions.

The capacity to categorise manuscripts based on their underlying nanoscale structure and, in particular, the orientation distribution of cellulose fibrils introduces a novel and efficacious instrument for the classification and grouping of heritage collections, including but not limited to manuscripts, paintings, ancient

papyrus scrolls and so forth. The creation of a database comprising measured orientation distributions of reference materials and their associated metadata would facilitate the utilisation of this approach for authentication purposes, thereby enhancing the capabilities of existing tools. At present, research is being conducted to demonstrate the feasibility of employing this methodology for the investigation of provenance. Many research fields are devoting more and more attention to heritage science and the SAXS technique could potentially contribute to it.

5 Conclusion

This chapter elucidates the potential insights that can be gleaned from a SAXS/WAXS examination of heritage artefacts. The potential of the SAXS/WAXS technique in the field of heritage science has not yet been fully realised. The coming years will undoubtedly yield further insights. In any case, the primary objective should be to perform multimodal investigations in order to gain as much knowledge as possible about the objects in question. Furthermore, it is of great importance to cross-validate the results obtained from the various measurement techniques employed.

Table 1: Summary of the colour palette determined by WAXS and the grouping of the cards based on the SAXS analysis.

Pigment analysis by WAXS/XRD	
Colour	Pigment mineral
yellow	gold and orpiment
green	malachite and azurite
red	cinnabar
white	kaolinite
blue/pink	indigo + Tibet phase
Grouping analysis by SAXS (fibrils orientation)	
Group	Card label
A	0, 3, 5, 9, 13, 15, 19, 20, 21, 22, 27, 28, 35, 36, 37, 39, 40, 42, 49, 55, 56, E, G, H
B	1, 2, 4, 6, 7, 8, 11, 12, 14, 16, 17, 18, 23, 24, 25, 26, 29, 30, 31, 32, 33, 34, 38, 43, 44, 45, 46, 47, 48, 50, 51, 52, 53, 54, 57, 58, A, B, C, D, F

The principal findings pertaining to the *tsakali* collection are presented in Table 1. The colour palette of the *tsakali* collection was determined through X-ray diffraction pattern analysis. 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. The analysis of the orientation of the cellulose fibrils 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.

Claudia Colini, Lucas F. Voges, Stephan Seifert

Chapter 8: Analysis of Paper Components with FTIR (DRIFTS) Spectroscopy

Abstract: In this chapter, Fourier transform infrared spectroscopy (FTIR), independently of microscopy, will be applied to study the *tsakali* paper components, especially for the identification of fillers, sizing agents and degradation processes. Previously, this was also used for fibre identification, although the presence of sizing and of multiple types of fibres in the same object might compromise the results. This method is based on the excitation of chemical bonds in a molecule by IR light with characteristic frequencies, resulting in specific types of vibrations. These vibrations are detected and recorded in spectra: the position and intensity of the peaks provide information about the chemical composition and crystalline structure or geometry of the molecule. Comparing reference spectra to those of unknown substances proved extremely effective for their identification. Furthermore, chemometric approaches like principal component analysis (PCA) will be applied for fingerprinting. PCA generates new variables (principal components) that represent the main variances of the spectra, and can thus be used to analyse the similarities and differences between them.

1 Introduction

Based on the sieve used for the formation of the writing support, described in Chapters 1 and 5, the *tsakali* can be divided into two main groups: laid papers (occurring only in three folios: set A, cards 23 and 25, and set B, cards D) and woven papers (occurring in all other instances). The woven papers can be further subdivided into two groups on the basis of the technological process received by the fibres: in fact, thirty-nine folios in set A and four of set B show the presence of bundles of unbeaten fibres, thereby resulting in a higher fibre density, while fifteen folios in set A and three in set B appear to have been more evenly pulped.

We applied Fourier transform infrared spectroscopy (FTIR) to study the *tsakali*, especially for the identification of additives, fillers and sizing agents that may have been added to the paper. As this technique has also been used for fibre iden-

tification in textile and paper objects in the past,¹ we calculated the intensity ratio of characteristic peaks to compare the paper of the cards. The results have been evaluated in light of the identification performed via optical microscopy (in Chapter 6). Furthermore, chemometric approaches like principal component analysis (PCA) have been applied to compare all the spectra and thus carry out a fingerprint analysis of the material. PCA generates new variables (called principal components) that represent the main variances of the spectra, and can thus be used to analyse the similarities and differences between them.

2 FTIR analysis

Fourier transform infrared spectroscopy (FTIR) is based on the excitation of vibrations of chemical bonds in molecules by characteristic frequencies of IR light. The light used for the excitation is detected and displayed in spectra, and the position and intensity of the absorption peaks in the spectra provide information about the chemical composition and crystalline structure or geometry of the molecules involved. The identification of the unknown substances is normally obtained by comparing their spectra to those of reference materials. FTIR spectroscopy has been successfully utilised for fibre identification in previous studies, though mostly in attenuated total reflectance (ATR) mode.²

In this study, a portable 4100 Exoscan FTIR spectrometer (Agilent) was used in diffuse reflectance mode (DRIFTS). This is a surface non-destructive and non-invasive mode, although it requires stable contact with the analysed object. In fact, the equipment was placed perpendicularly to the object, touching it. The spectrometer is equipped with a ZnSe beam splitter, a Michelson interferometer and a thermoelectrically cooled dTGS detector. It has a spectral range of 4000 to 650 cm^{-1} and a spectral resolution of 4 cm^{-1} . A gold reference cap was used for background calibration and 256 scans were collected. Chemometric analysis was carried out in R 4.2.3³ with the packages *hyperSpec*,⁴ *EMSC*⁵ and *prospectr*.⁶

Measurements of the *tsakali* were done in triplicate on the unwritten paper area for fifteen cards. Nine cards from set A (3, 7, 8, 19, 23, 25, 49, 51, 55) and six

¹ See e.g. Garside and Wyeth 2003; Espejo et al. 2010; Peets et al. 2019.

² See e.g. Garside and Wyeth 2003; Espejo et al. 2010; Peets et al. 2019.

³ The R Core Team 2022.

⁴ Beleites et al. 2021.

⁵ Liland 2021.

⁶ Stevens and Ramirez-Lopez 2025.

cards from set B (B, C, D, E, F, G) were analysed. The raw data is available at the Research Data Repository of Universität Hamburg under CC BY 4.0.⁷

Spectra were imported in a hyperSpec R object, and the spectral range was subsequently reduced to 700 to 3800 cm^{-1} . Extended multiplicative scatter correction (EMSC) was applied to reduce scattering and apply normalisation. Smoothing (together with the first or second derivative) was applied with a window size of 11 spectral points (resulting in a total range of 20.5 cm^{-1}) and a polynomial order of two. Baseline correction was achieved with polynomial baselines (polynomial order 1).

3 Results

All the peaks present in the spectra are compatible with the expected peaks associated with cellulose, hemicellulose and lignin. By comparison with reference spectra of substances used in papermaking in Asia and Europe, no fillers, additives or sizing could be identified.

The paper of the *tsakali* was analysed to see whether the two sets or the paper types had an influence on the resulting spectra. Principal component analysis (PCA) was used to visualise and detect whether differences in absorbance can be connected with the paper type or manuscript sets. The spectral range between 1900 and 2400 cm^{-1} was not included in the PCA, as signals from air carbon dioxide and monoxide are located here. After preprocessing, the spectra were comparable in intensities (see Fig. 1) and were used for PCA. The first and second derivatives were also used for PCA, as they are not influenced by the baseline.

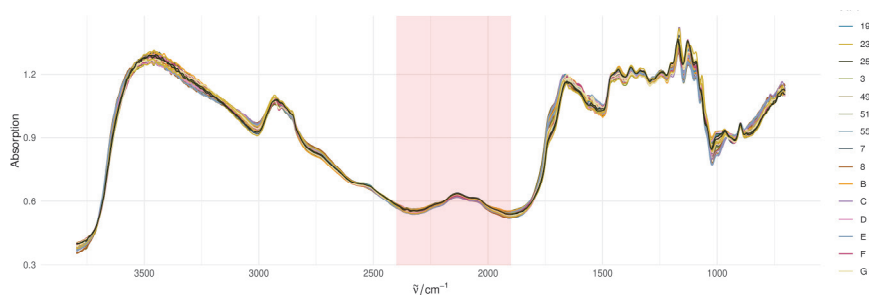


Fig. 1: Spectra after preprocessing (EMSC; smoothing and spectral range reduction to 700 to 3800 cm^{-1}). The area in light red was not used in the PCA.

⁷ Voges, Horn and Seifert 2024.

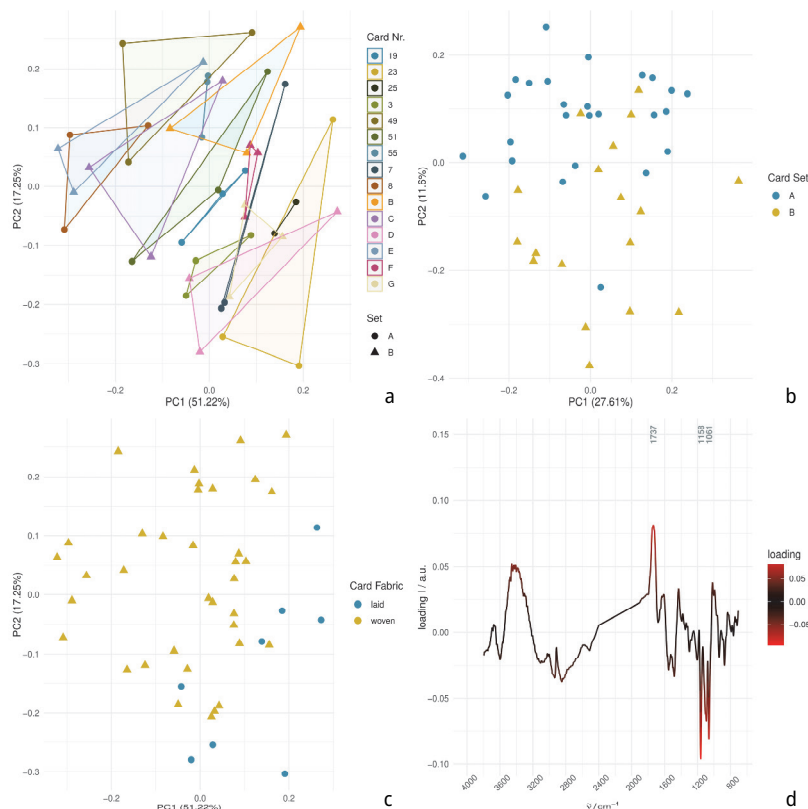
The results of the PCA are shown in Figs 2a–d. Around 50 per cent of the variance can be explained by the first component, and no differences separating the sets can be observed for the preprocessed spectra (Fig. 2a), while, in the second derivative (Fig. 2b), a trend seems to emerge. When considering the paper type, the scores of the principal components in the preprocessed spectra (Fig. 2c) seem to present some differences. The corresponding loadings for the first and second components (Fig. 2d) indicate that the peaks around 1737 cm^{-1} , 1000 to 1100 cm^{-1} and, in the higher wavenumbers, around 3400 to 3600 cm^{-1} are mainly responsible for these differences. The loadings in the first derivative present the same results (not shown here) with the addition of a strong contribution of the peak at 1160 cm^{-1} , which, therefore, might be the main reason for the paper type separation.

The peaks identified by the PCA analysis as contributing to the differentiation of paper types and card sets can be assigned to the relevant bonds present in the cellulose, hemicellulose and lignin, which are the main components of paper materials.⁸ The area around 3500 cm^{-1} can be assigned to OH valence vibration and may indicate different cellulose compositions of the paper types. The peak around 1170 cm^{-1} is sometimes shifted to lower wavenumbers (1166 – 1160), and from the first derivative, this peak has an impact depending on the paper type. This peak may be assigned to asymmetric C-O-C valence vibrations, and can be caused by cellulose and hemicellulose as well as by lignin. The area between 1000 and 1130 cm^{-1} can be assigned to C-O valence vibrations of the functional groups of primary and secondary alcohols found in cellulose, hemicellulose and lignin.

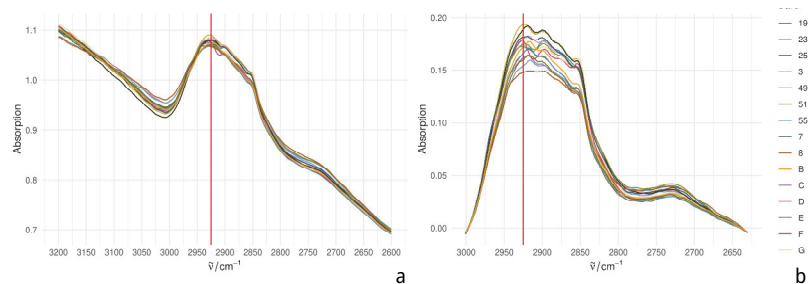
To analyse the paper types in detail, various bands from cellulose, hemicellulose and lignin have been compared as intensity ratios as described by Paul Garside and Paul Wyeth.⁹ Three ratios have been calculated from the spectra using peaks at 2925 cm^{-1} (general organic content, C-H vibration), 1595 cm^{-1} (lignin, C=C vibration) and 1110 cm^{-1} (glycosidic ether, mainly cellulose, C-O-C vibration) – in the same way as reported by Garside and Wyeth – with the addition of the peak at 1740 cm^{-1} (C=O vibration, corresponding to the carbonyl groups of oxycelluloses and lignin in the case of degraded materials or, though less likely in the case of paper, to pectin), as it was a promising feature identified by the PCA loadings. Intensities were measured at the mentioned wavenumbers on the raw, preprocessed and local baseline-corrected spectra. The baseline for the corresponding peaks was fitted in the spectral ranges 2600 – 3200 cm^{-1} , 1485 – 1780 cm^{-1} , 1025 – 1185 cm^{-1} and 1670 – 1800 cm^{-1} .

⁸ Garside and Wyeth 2003; Peets et al. 2019.

⁹ Garside and Wyeth 2003.



Figs 2a–d: (a) PCA of preprocessed spectra, with polygons highlighting the individual cards; (b) PCA of the second derivative of the spectra, with different highlighting of the cards, set and paper type; (c) PCA of preprocessed spectra, with fabric type indicated by colour; and (d) loading plot for the second component of the PCA (peaks with the highest absolute values are marked [cm^{-1}]).



Figs 3a–b: Mean spectra for each *tsakali* measured. (a) Preprocessed spectra. (b) Spectra with base-line fitted. The red vertical line shows the peak position at 2930 cm^{-1} used for the analysis.

An example of the differences in the baseline fitted and preprocessed spectra can be seen in Figs 3a–b for the 2925 cm⁻¹ peak. The mean values of the calculated ratios and their standard deviation are listed in Table 1.

Table 1: Mean values with standard deviation for the peak intensity ratios for the different paper types of spectra with different processing.

Spectra	Paper Type	R1 (1595/1110)	R2 (1595/2925)	R3 (1735/2925)
Raw	laid	0.86 ± 0.02	1.03 ± 0.01	0.80 ± 0.02
	woven	0.90 ± 0.03	1.05 ± 0.01	0.87 ± 0.04
Preprocessed	laid	0.87 ± 0.02	1.03 ± 0.01	0.81 ± 0.01
	woven	0.90 ± 0.02	1.05 ± 0.01	0.87 ± 0.03
Baseline	laid	1.09 ± 0.18	1.12 ± 0.08	0.31 ± 0.03
	woven	1.15 ± 0.15	1.28 ± 0.09	0.49 ± 0.14

Although the preprocessing and especially baseline fitting have a strong influence on the spectra, the ratios are quite robust regardless of the different processing. This is true except for R3, with baseline correction, which could be based on the fact that 1735 is a shoulder peak, hence the baseline correction is more strongly influenced by the neighbouring peaks.

We compared the values of the ratios obtained in this study with (1) the intensity ratios obtained by Garside and Wyeth¹⁰ for flax, jute, hemp, cotton, ramie and sisal (both native and processed fibres); and (2) the theoretical spectral regions corresponding to flax, jute, hemp and cotton, calculated by Teresa Espejo, Adrian Duran, Ana Lopez-Montes and Rosario Blanc¹¹ from the materials' theoretical percentages of cellulose, hemicellulose, pectin and lignin. Such comparison did not lead to any identification of fibres, as our values fell in different spectral regions. As demonstrated by Pilleriin Peets, Karl Kaupmees, Signe Vahur and Ivo Leito,¹² however, the position, shape and intensity of peaks change from ATR to DRIFTS, which might be the reason why no identification could be obtained. Additionally, the fibres were identified as *Stellera* with the possible admixture of *Daphne* fibres, according to optical microscopy (see Chapter 6), species that were not considered in the previous studies, and for which we do not have intensity ratios. In the

¹⁰ Garside and Wyeth 2003.

¹¹ Espejo et al. 2010.

¹² Peets et al. 2019.

future, we intend to build our own reference library in reflectance, including additional fibres used in Asian papermaking, in order to be able to compare the sets of data.

The scatter plot of the three ratios based on the preprocessed spectra is shown in Fig. 4; it is worth mentioning that for all the different types of processing, the plots show comparable results. As previously mentioned, the same mixture of fibres was found in all the *tsakali* paper analysed; however, all three ratios, but particularly R2 (1595/2925) and R3 (1735/2925), show a strong separation between high- and low-fibre density paper. This is to be expected, as the presence of fibre bundles is naturally associated with a higher content of lignin, found in the macrofibre walls, as well as with a shorter time of cooking. Furthermore, lignin oxidises faster than cellulose, resulting in the formation of additional carbonyl groups¹³ and thus in higher values of R3. R3 also shows a separation between paper types, with lower values connected to laid paper, perhaps suggesting that different sheet formations might play a role in paper degradation. However, the separation between paper types is ambiguous at the area of overlap between the two types, which is still reasonable, as the material is inhomogeneous and there are many factors influencing the measurement. Hence, for measurements of this kind, it is advised to take the mean of multiple measurements from the sample, as ratios from the same card can show fluctuations.

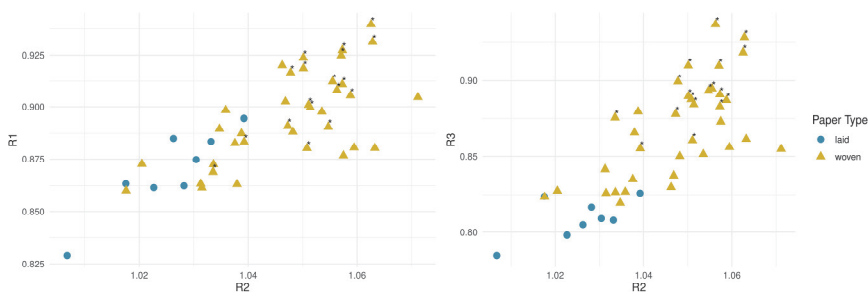


Fig. 4: Scatter plots for ratios R1/R2 and R3/R2 woven paper type with high fibre density are marked with asterisks. The peak intensities are from the preprocessed spectra.

4 Conclusions

The analysis with ratios proves to be a very robust method to measure differences in the paper types. The peaks identified in ATR by Garside and Wyeth¹⁴ for the calculation of ratios R1 and R2 do not correspond precisely to those in DRIFTS, as the latter seems to be broader and shifted to higher wavenumbers.¹⁵ Further investigation of other relevant peaks determined by PCA (such as the one at 1735 cm⁻¹, which we used to calculate R3) could advance the identification of paper types and the understanding of their composition. This workflow shows a promising application to written artefacts.

As for the identification of plant fibres through the calculation of R1 and R2, it must be remarked that paper is the result of a complex set of procedures and materials, and that several variables (i.e. the part of the plant used, the extent of pulping, the addition of sizing agents like starch glue and the use of a mixture of fibres) can contribute to the alteration of these ratios. This very case study is an example of such inherent data contamination, as papers with the same plant fibres, but with high- and low-fibre density due to different pulping processes, resulted in different ratio values.

¹⁴ Garside and Wyeth 2003.

¹⁵ Peets et al. 2019.

Sebastian Bosch, Olivier Bonnerot, Sowmeya Sathiyamani

Chapter 9: Multi-instrumental Analysis of Pigments and Dyes

Abstract: This chapter presents the results of various instrumental analyses applied to study the wide range of different colourants found in the *tsakali*. These are paints based on mineral pigments, dyes derived from plants or mixtures of both. The results of the multispectral data prepared by Ivan Shevchuk and Kyle Ann Huskin (see Chapter 4) served as a starting point for further non-invasive analysis using XRF scanning, Raman spectroscopy, FTIR spectroscopy and FORS. Measurements taken from six different *tsakali* are compared to each other, aiming at the identification of their colourants.

1 Introduction

As mentioned above, the *tsakali* contain a wide range of different colourants, such as paints based on mineral pigments, dyes derived from plants or mixtures of both. The uniqueness of the area of Tibet and Central Asia originates from the extreme climatic conditions and range of altitudes in the region, characterised by both the highest Himalayan ranges, with their deep valleys, and the deserted regions of Central Asia. It is probably why, besides the common materials composing these books, some local materials are also found. These rarer local materials are good references for further comparative studies.

The multi-instrumental analysis of the colourants was conducted after the MSI investigation described in Chapter 4. This was useful not only because it provided us with good-quality digital images of the *tsakali* to document the analysis, but also because the post-processing analysis already hinted at features of interest, such as different colourants used for red backgrounds. We focused our analysis on six cards (0, 1, 3, 25, A and D), which appear representative of the different colours (yellow, red, blue, green, orange, gold, black, white and pink) observed. To be able to analyse and identify both organic dyes and inorganic pigments, we used a combination of four non-destructive and non-invasive techniques: X-ray fluo-

rescence (XRF) scanning, Raman spectroscopy, Fourier transform infrared (FTIR) spectroscopy, and fibre optic reflectance spectroscopy (FORS).¹

2 Methods

2.1 X-ray fluorescence scanning

X-ray fluorescence (XRF) spectroscopy has become one of the most commonly used analytical techniques for non-destructive material analysis of cultural artefacts, including miniatures on manuscripts, usually in combination with other non-invasive techniques.² There is now a wide range of XRF devices available, ranging from handheld portable spectrometers for quick on-site analysis to bulkier but more precise scanning devices, some of which are transportable. Since the *tsakali* were brought to our laboratory, we were able to use a large scanning device without the effort of transporting it. The analysis was performed using an M6 Jetstream (Bruker Nano GmbH) large-area μ -XRF scanner. This device has an adjustable measuring spot ranging from 50 to 650 μm and is equipped with a low-power Rh X-ray tube, polycapillary X-ray focussing optics, a 50 mm² Xflash SDD detector and two microscopes for positioning. Since scanning is conducted in air atmosphere, only elements heavier than magnesium (Mg) can be securely identified. All the measurements were performed at 50 kV and 600 μA , with a spot size of 50 μm , an acquisition time of 15 ms / pixel and a pixel (step) size of 150 μm . The concentration of an element within the volume sampled is related to the counts detected for that element, making the method suitable for quantitative analysis in theory (at least for bulk materials, with the use of correcting algorithms and standards).³ However, a number of other factors, such as the fluorescence yield (different for each element) and matrix effects (absorbance and fluorescence of the matrix in the X-ray region of the electromagnetic spectrum), also affect the counts detected. Furthermore, the nature of the objects to be analysed, such as the unknown thickness of the inks and colourants applied to the heterogeneous paper support, makes straightforward analysis difficult, so that in practice, only semi-

¹ The complete dataset is available in Bosch et al. 2025.

² See, for example, Moura et al. 2007; Deneckere et al. 2011; Aceto et al. 2012; Guerra et al. 2013; Mosca et al. 2016; Ricciardi et al. 2016; Bosch and Janke 2021; Brocchieri et al. 2021; Biolcati et al. 2023; Koochakzadeh, Mobasher Maghsoud and Jelodarian Bidgoli 2023; Jembrih-Simbürger et al. 2024.

³ Mantler et al. 2006.

quantitative results (e.g. comparing element intensities in different areas of the paper) can be achieved.

2.2 Raman spectroscopy

Raman spectroscopy is widely used in archaeometry, in particular for the non-destructive identification of pigments.⁴ As with XRF devices, mobile Raman spectrometers allow on-site analysis, but at the expense of larger spot sizes and lower spectral resolution. Since the *tsakali* were brought to our laboratory, we were able to use a more powerful benchtop instrument. The analysis was performed with a Renishaw inVia spectrometer, fit with optic fibres to be able to accommodate larger objects. All the measurements were performed using a long focal 100× magnifying lens, allowing for the investigation of small details (spot size of about 10 µm diameter), and with the following parameters: integration time of 1 to 5 s, 10 to 50 scans, 2 to 6.3 per cent laser power (< 3 mW), 785 nm (near infrared) and 532 nm (green) lasers.⁵

2.3 Fourier transform infrared spectroscopy

Fourier transform infrared (FTIR) spectroscopy is another popular technique in the field of cultural heritage, and is usually used to complement Raman spectroscopy when analysing colourants. FTIR spectroscopy employs several modes for analysing different types of samples and objects. In the field of non-destructive and non-invasive analysis, either external reflectance (ER) or diffuse reflectance infrared Fourier transform spectroscopy (DRIFTS) is used depending on the nature of the object. While the DRIFTS mode is particularly suitable for larger object areas (in the centimetre range) and rough surfaces such as paper,⁶ the ER mode enables the analysis of very small (in the millimetre range), non-rough surface structures and provides a non-destructive way for the characterisation of both the

⁴ See, for example, Burgio, Ciomartan and Clark 1997; Clark 1999; Bicchieri, Nardone and Sodo 2000; Deneckere et al. 2011; Aceto et al. 2012; Guerra et al. 2013; Mosca et al. 2016; Marucci et al. 2018; Biolcati et al. 2023; Koochakzaei, Mobasher Maghsoud and Jelodarian Bidgoli 2023.

⁵ The main shortcoming of this technique is the competition of the Raman scattering with fluorescence when enough energy is provided to the molecule analysed for electronic transitions to occur. As fluorescence can sometimes mask the Raman signal completely, it is important to try to minimise it. Using a different laser is one of the main strategies to achieve that.

⁶ See Chapter 8.

writing supports and the inks and colourants used.⁷ However, the spectra acquired with the ER mode are often affected by distortions that sometimes lead to inverted peaks and peak shifts when compared to spectra acquired with other modes. This can complicate the interpretation of the results. The device we used to investigate the colourants of the *tsakali* is the compact Alpha II (Bruker Optics GmbH) FTIR spectrometer, which was placed perpendicularly to the object with slight contact to the surface. The spectrometer is equipped with an ER module and an integrated video camera for the positioning of the exact measuring spot. This setup allows for the rapid investigation of the object with an interaction spot size of 4 mm. The spectrometer is further equipped with a thermoelectrically cooled DLaTGS (Deuterated Lanthanum α Alanine doped TriGlycine Sulphate) detector allowing for measurements in a spectral range of 4000 to 400 cm^{-1} and a spectral resolution of 2 cm^{-1} . A gold reference cap was used for background calibration, and sixteen scans were collected per measurement.

2.4 Fibre optic reflectance spectroscopy

Fibre optic reflectance spectroscopy (FORS) is another common technique for the non-destructive identification of pigments and dyes, as it is very easy to use and devices are usually very compact and easily portable. This, however, comes at the expense of lower accuracy and spatial resolution. Therefore, the method is mostly employed as a rapid tool for preliminary analysis.⁸ The device we used to investigate the colourants of the *tsakali* is the compact Labspec 4 HR (Malvern Panalytical) equipped with an integrated halogen light source. The spectrometer is coupled with one VNIR detector and two thermoelectrically cooled short-wavelength (SWIR) detectors with an InGaAs photodiode. The interaction spot dimension is c. 2 mm. The reflectance spectra were collected in the spectral range 350 to 2500 nm with a spectral resolution of 3 and 6 nm at 700 and 1400/2100 nm, respectively; a sample count of 50; and a scanning time of 34 to 136 ms. The raw reflectance spectra were further transformed into first derivative spectra in order to extract inflection points.⁹

⁷ Nodari and Ricciardi 2019.

⁸ Aceto et al. 2012; Aceto et al. 2014; Pronti et al. 2018; Brocchieri et al. 2021; Koochakzaei, Mobasher Maghsoud and Jelodarian Bidgoli 2023; Jembrih-Simbürger et al. 2024.

⁹ Aceto et al. 2014.

3 Results

This section summarises the results of the study of the colour palette of the *tsakali* based on the evaluation of the multi-instrumental analysis with non-destructive XRF scanning, FORS, Raman and FTIR spectroscopy. The analysis was carried out on six cards (Tsakalis 0, 1, 3, 25, A and D) and led to similar results in the identification of the colourants and inks for all the cards examined. Table 1 summarises the results and shows the broad palette of different materials used to create these cards.

Table 1: Summary of the materials identified used in the *tsakali* from the Zhangzhung Nyengyü collection.

Colour	XRF	Raman	FTIR	FORS	Assignment
red	Hg, S, Zn	cinnabar	-	cinnabar	cinnabar
orange	As, S	orpiment, cinnabar, pararealgar (Tsakali 3)	-	-	orpiment (mixed with cinnabar)
yellow	As, S	orpiment	-	orpiment	orpiment
green	Cu, Fe, Mn	malachite, azurite, indigo, orpiment, carbon	malachite, azurite, indigo	malachite azurite, indigo	malachite or indigo/azurite + orpiment (mixed with carbon)
blue	Fe, As	indigo, carbon	indigo	indigo	indigo (dark blue mixed with carbon)
pink	Fe, As, Zn	-	-	-	-
gold	Au, Zn	carbon, orpiment	-	-	gold (on top of other colourants)
white	-	-	kaolinite	-	kaolinite
black	-	carbon	-	-	carbon
black ink (Tsakalis 25 and A)	-	aniline	-	-	aniline

The final assignment of all the applied pigments, dyes and inks used was only possible by combining the above-mentioned techniques. In a first step, the cards were subjected to XRF scanning that enables the analysis of large areas, which ultimately provides a representative characterisation of the heterogeneous objects and minimises errors due to material inhomogeneity. The evaluated data is

presented in the form of element maps that display the elemental distribution across the surface of the cards with high spatial resolution. Fig. 1 shows the results of Tsakali D, which already allow for the assignment of some colourants, such as real gold (Au) used to paint the jewellery, crowns and other highlights, and cinnabar (mercury sulphide (HgS) with zinc (Zn) as an impurity) used for the red areas. Other materials used cannot be clearly determined due to the limitations of the XRF method. Since no light elements such as carbon can be detected with the applied XRF instrument, the method does not allow for the determination of organic dyes or inks. Furthermore, the detection of certain elements can indicate a variety of different materials or their mixture.

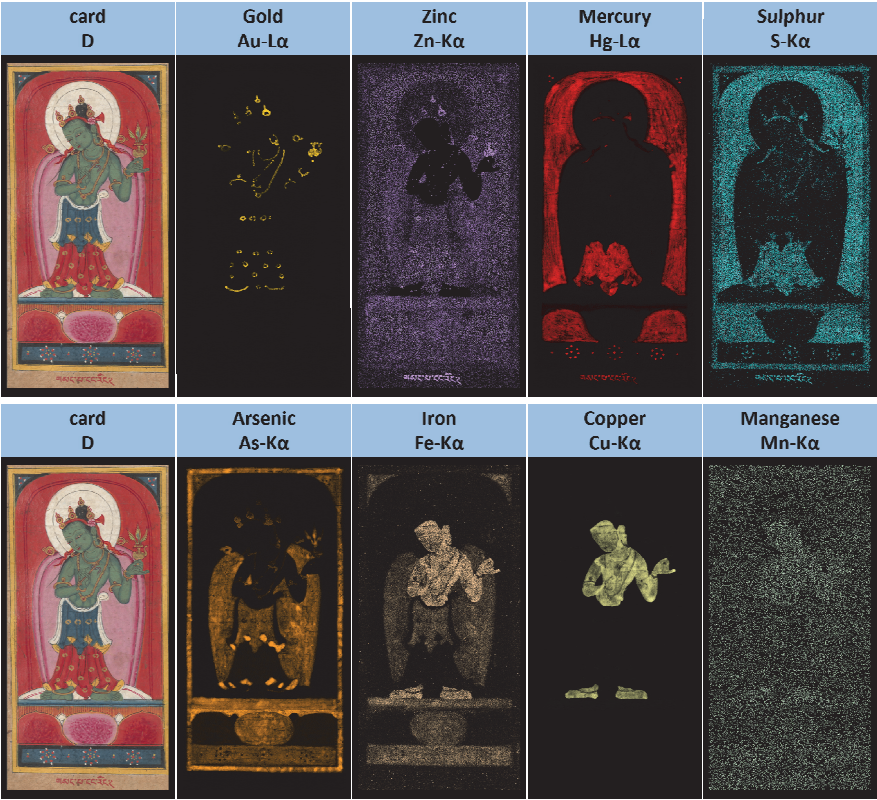
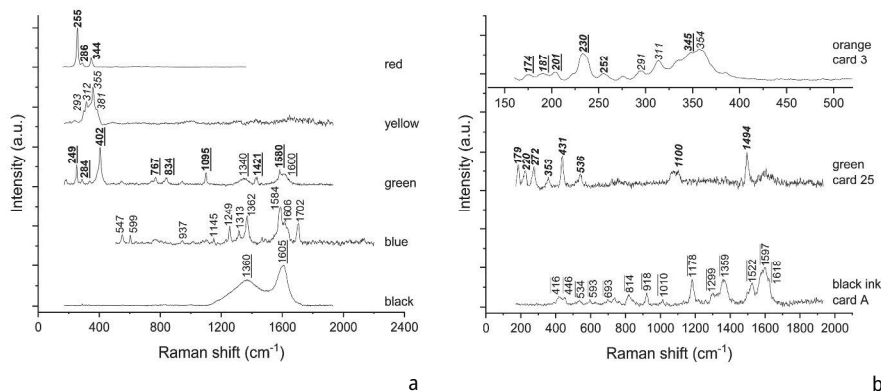


Fig. 1: XRF element maps for Tsakali D showing the distribution of the detected elements.

The XRF results can be further specified with the aid of Raman spectroscopy. This method allows the unambiguous determination of many inorganic pigments, organic dyes and black inks based on characteristic signals in the Raman spectra. Based on the XRF results, it was possible to select certain locations that required further spectroscopic measurements. The Raman results are summarised for Tsakali D in Fig. 2a. The other cards showed identical results; however, in some areas we found additional materials, which are presented in Fig. 2b. For the red areas, the Raman measurements clearly identified cinnabar and thus confirm the XRF results. Orpiment was evidenced for the yellow and orange areas. These results are also consistent with the XRF results, as here mainly arsenic (As) and sulphur (S) were detected. Some pararealgar, mixed with orpiment and cinnabar, was also found at an orange spot on Tsakali 3. In the case of the green areas, the Raman measurements detected a variety of colourants. A rich variety of hues were obtained by mixing blue indigo and azurite, yellow orpiment and green malachite with carbon. The identification of azurite and malachite is consistent with the XRF results, which show a high content of copper (Cu) in these areas. Indigo and carbon could not be evidenced by XRF, as the detection of light elements is limited. The Raman results were further verified by FTIR measurements (Fig. 3), which confirmed malachite, azurite and indigo in the green areas. Indigo was also detected in the blue areas. Carbon black was found in several spots, mixed with other pigments and dyes in order to obtain darker hues.



Figs 2a–b: Raman spectra obtained for spots of different colours, after baseline subtraction, with the observed main peak positions marked. (a) From Tsakali D; (b) other pigments and dyes not detected on Tsakali D, but identified on other cards. Normal: indigo; underlined: carbon black; bold underlined: azurite; bold italic: malachite; italic: orpiment; bold: cinnabar; bold italic underlined: pararealgar; overlined: black dye (closest match aniline).

On two of the cards investigated, Tsakalis 25 and A, there is a line written in black ink below the image. For both cards, the Raman spectra obtained for this ink do not match the expected carbon or iron-gall inks. Instead, the spectrum fits closely with that of aniline black, a synthetic pigment that was mainly used between the end of the nineteenth century and the 1930s.¹⁰ Since such ink was not available at the alleged time of making of the *tsakali*, these lines must be a later addition, possibly related to their use in rituals.

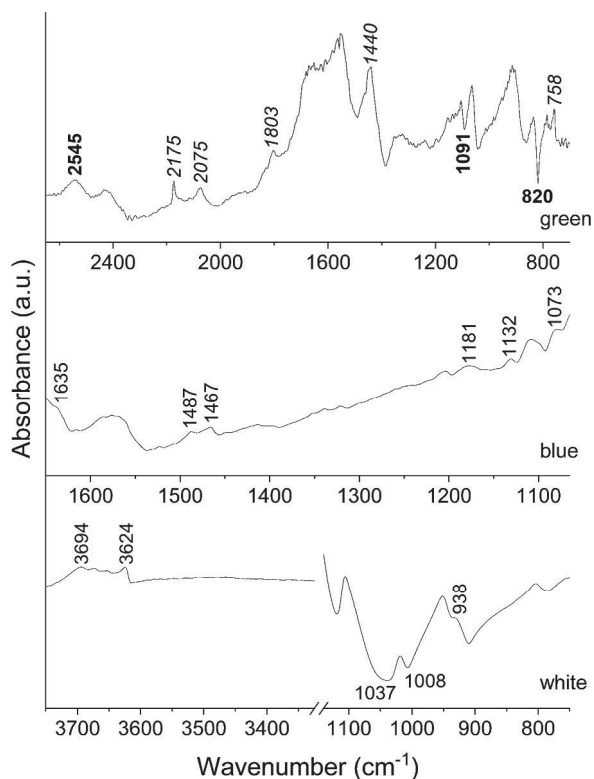


Fig. 3: FTIR spectra obtained for spots of different colours from Tsakali D, with the observed main peak positions marked. Top, bold: malachite; top, italic: azurite; middle: indigo; bottom: kaolinite.

¹⁰ Travis 1994.

For the white and pink areas, unfortunately the Raman signal was completely masked by fluorescence, even when using a laser with lower energy (785 nm), a well-known issue of this technique.¹¹ This again shows the importance of multi-instrumental analyses, as the white pigment kaolinite could only be detected with FTIR (Fig. 3). Only the pink pigment could not be identified despite extensive analyses. Interestingly, the XRF scans of both the pink and blue areas show the elements arsenic (As) and iron (Fe). As already mentioned in Chapter 7, it has been determined that these areas were painted with a mixture of indigo and a previously undiscovered pigment, designated as the Tibet phase.¹²

4 Conclusion

This chapter demonstrates the power of multi-instrumental analysis using non-invasive equipment for the identification of a wide range of artists' materials. The pigments and dyes used for the production of the *tsakali* are consistent with the supposed date of their production (fifteenth century). Furthermore, the palette is very similar to that identified by Jessica Brocchieri, Laurence Viguerie, Carlo Sabbarese and Marion Boyer for Buddhist thangka paintings, with the exception of minium and calcite, which we did not detect in the *tsakali*.¹³ Interesting findings of this study are, on the one hand, the detection of real gold, which was used as a very precious material for some highlights on the cards, as well as the use of quite a modern black ink, which was most certainly added at a later phase. Finally, the results are consistent with those in Chapter 7 and served as the basis for an in-depth study to investigate a previously unidentified pigment.¹⁴

¹¹ Edwards, Vandenabeele and Colomban 2023, 23–24.

¹² Haas et al. forthcoming.

¹³ Brocchieri et al. 2021.

¹⁴ Haas et al. forthcoming.

Tomasz Goslar, Agnieszka Helman-Ważny

Chapter 10: Radiocarbon Dating of *Tsakali* Paper

Abstract: This chapter discusses the possibilities and limitations of the radiocarbon accelerator mass spectrometry (AMS) dating applied to date the Zhangzhung Nyengyü *tsakali* collection (the set of sixty-five initiation cards). Our report discusses the specificity of dating paper as a material, including the sample preparation (extraction of cellulose), the development of the AMS method that allows for minimising the size of the samples, and how to read the calibration line of ^{14}C dates.

1 The *tsakali* paper

The objects of the radiocarbon dating are two Tibetan initiation cards (*tsakali*) selected from the set of sixty-five belonging to the Zhangzhung Nyengyü system of the Bon religion, the subject of this book. On the recto sides, they bear the polychrome image of a divinity, saint or sacred object, and on the verso sides, a passage of text of varying length citing a scripture related to the corresponding image.

This Zhangzhung Nyengyü *tsakali* set is not conclusively dated by its text or other features that would allow for sure dating. The art-historical analysis by Christian Luczanits (see Chapter 3) suggests that the style of painting could have been commonly associated with the fourteenth century. However, this style is archaising, and some of the elements found in some figures – such as the lower garment of the Buddha's clothing – indicate a somewhat later date. Some figures depicted on the *tsakali* were possible to identify, so we know that these cards were not painted before the lifetimes of these people, but we could not say when these people were depicted. Further, X-ray scattering methods suggest the use of the blue pigment, that is a mixture of indigo and a previously undiscovered pigment, designated as the Tibet phase. The crystal structure of this pigment phase could not be resolved but was somehow similar to Prussian blue that may not have been used in the fourteenth century (see Chapter 7).

The *tsakali* are used in initiation rituals to empower neophytes in the particular domain of religion they represent. Once a tool for passing down knowledge from master to student, the set may have been designed and produced specifically for a person at a particular level of spirituality. It is also possible that certain cards were produced later as the learning process continued. Thus, it is obvious that the story of the production and usage of this heritage object is more complicated. This spurred the need for a cross-disciplinary analysis of the set, including undertaking the independ-

ent method such as radiocarbon dating, which would help to narrow down the time period in which the *tsakali* were produced.



Figs 1a–b: (a) Tsakali O, depicting a *bum pa* vase, and (b) Tsakali D, showing the figure of gSang ba ngang ring.

Considering the above-mentioned hints, the object of our study is a part of the cultural heritage of Tibet. This is why the possibilities for sampling are very limited, and only the AMS method can be considered (smaller samples are required). Because ^{14}C is a destructive method, for a historical object such as this, we decided

to start our research with just one sample, and postponed dating any other cards until we received the results obtained by the other methods. Moreover, the sampling was discussed with the owner of the object, whose permission was obtained. All the cards are cut to the same dimensions (9.4 cm in width × 20.2 cm in height) and made of paper; however, the numbering added later on suggests that we are dealing with at least two different sets within this collection. Each card bears a number or letter indicating the sequence of the card in the collection. The paper they are made of also consists of two types, suggesting that different papermaking sieves were used in its production. This is why the samples considered for ^{14}C analysis were selected from two cards bearing different features.

The first sample was taken from a damaged area of *Tsakali* O, depicting a *bum pa* vase; later, a second sample was taken from *Tsakali* D, showing the figure of *gSang ba ngang ring* (Figs 1a–b). The selection of sample locations was conditioned by (1) no materials other than paper being present, (2) no damage, like fungi spores or other marks of degradation, being visible.

2 Dating paper by radiocarbon method

Radiocarbon dating is applicable to manuscripts composed of organic materials; using milligram-sized samples, it has been used to estimate the age of books as well. Though impractical in its early decades, when as many as several grams of carbon were needed for ^{14}C measurement, the radiocarbon method became a more convenient tool for dating paper after the AMS technique was invented, requiring carbon amounts of 1 mg or even less. It is independent of other methods, objective, and the only truly quantitative method for dating organic materials. However, as many scholars have pointed out, this technique alone usually cannot resolve issues of authenticity or provide precise dating.

The calculations of the $^{14}\text{C}/^{12}\text{C}$ ratio in organic materials produce ages in radiocarbon years, which are not identical with calendar years (as the mentioned $^{14}\text{C}/^{12}\text{C}$ ratio has not been constant historically). The study of tree rings (as a sequence of securely dated samples) has allowed us to produce a so-called ‘calibration curve’ that relates calendar dates to radiocarbon ages.¹ Using this curve, one can calibrate radiocarbon age, i.e. derive a calendar date from the results of ^{14}C measurement. As seen from the wiggly shape of the calibration curve shown in Figs 2a–b, the calibrated date (being the best estimate of calendar date) usual-

¹ The most recent calibration curve has been published by Reimer et al. 2020.

ly has a probability distribution of complex shape and – even if ^{14}C age is determined with a 1-sigma uncertainty of ± 30 yr – may encompass a time interval as wide as fifty to three hundred years, depending on the date itself. There exist various internationally-used software for calibrating ^{14}C ages, one of the most popular being OxCal.²

However, the precision of the measurement does not depend only on the object's time period or the calibration curve. It is very important to understand the material composition of the sample tested. Paper as writing support, with all its components, is a very complex and unique material, which is why it is difficult to understand at the molecular level, especially considering that a large number of its components undergo both technological and deterioration processes occurring at different stages and times, as well as the influence of various environmental factors. Thus, we have to clearly understand which point of the heritage object's life we are dating.

^{14}C analysis reveals only the period of formation of the plant cellulose molecules in the paper's fibres, and not the period of the paper's manufacture; the papermaking process will sometimes blend fibres from a wide variety of original sources, harvested at different times. An obvious obstacle to the accurate ^{14}C dating of paper industrially produced from the trunks of trees that had grown for decades is that ^{14}C signal of each tree ring represents the time of its formation (and not that of cutting the tree), so the ^{14}C signature of paper is an average of radio-carbon signals from many years, with individual years being unknown. In this respect, however, the age of the cellulose in the *tsakali* paper truly represents the time of the paper's manufacture, as it was made from the phloem of living plants, i.e. from the carbon-bearing tissue assimilated in the year of harvesting, or only very shortly before. Other substances, such as dyes or fillers, may have been added when processing the paper before writing, and organic materials may be found in pigments and other substances applied later on. These may contaminate samples with carbon of lower or higher ^{14}C signatures, which also may make the results of ^{14}C dating disputable.

3 Methods: A short overview

A sample of paper submitted to ^{14}C dating contains carbon in various chemical fractions, potentially of different ages and different ^{14}C isotopic signatures. Thus,

² Bronk Ramsey 2009.

the crucial goal of chemical pretreatment is to extract the fraction that is most representative of the true time of paper production. The remaining steps of the ^{14}C dating procedure, i.e. deriving pure carbon from this fraction and making AMS $^{14}\text{C}/^{12}\text{C}$ measurements from it, are more or less common to all AMS radiocarbon laboratories.³

In general, the paper fraction most suitable for dating is cellulose, which constitutes the walls of wood cells; after its formation, it is extremely resistant to the exchange of carbon inside the plant of origin (e.g. inside the tree trunk) and – after the tree is cut and paper produced – with the ambient environment.⁴ Besides cellulose, other organic fractions of wood are lignins, waxes and resins, which are potentially mobile in plants and to some degree also in the environment. The carbon pool produced in the ancient paper (containing also that of dyes and fillers, mostly contemporary with the time of paper production) may then, during the long period between its production and today, be modified due to the absorption of fulvic and humic acids (organic fractions mobile in humic environments) and eventual precipitation of carbonates. Ultimately, sample material may be contaminated with organic impregnates/preservatives and/or simply with fats deposited during its handling by humans.

An extensive review of chemical pretreatment protocols used for AMS ^{14}C dating⁵ has recommended the method coded as VV for paper, consisting of sequential treatment with 1M (c. 4%) HCl (20°C–80°C) to remove fulvic acids and carbonates; 0.2 M (c. 1%) NaOH (20°C–80°) to remove humic acids; and another treatment with 1M HCl to remove the carbon absorbed from atmospheric CO_2 during the treatment with NaOH, with temperatures adjusted individually in order to prevent the complete dissolution and loss of the sample material.

Referring to the main sources of paper contamination, examples of successful ^{14}C dating of ancient paper describe several versions of the chemical treatment applied. In the ^{14}C dating of the *miidera-gire* Japanese calligraphy sheets, dated between 1400 and 1200 years old, Hirotaka Oda treated the paper with a procedure very similar to that of the VV protocol outlined by Fiona Brock.⁶ More rigorous processing – in which the VV protocol was preceded by treatment with organic solvents to remove contamination from oils and waxes – was applied in dating manuscripts between 1200 and 200 years old from the Central Library of the Uni-

3 See Goslar, Czernik and Goslar 2004 for an example.

4 See e.g. Němec et al. 2010.

5 Brock et al. 2010.

6 Oda et al. 2011; Brock et al. 2010.

versity of Tehran.⁷ On the other hand, Buddhist sutras from the twelfth to fourteenth centuries⁸ were dated by measuring ¹⁴C in the cellulose extracted from these materials.

4 ¹⁴C dating of *tsakali* paper

The ¹⁴C dating of the *tsakali* paper was performed at the Poznań Radiocarbon Laboratory.⁹ After the chemical pretreatment of a sample, combustion of residue to CO₂, reduction of CO₂ to graphite, and AMS ¹⁴C measurement of the graphite, the conventional ¹⁴C age of the sample was calculated,¹⁰ then calibrated against INTCAL20¹¹ using OxCal ver. 4.4.2.¹² The determined ¹⁴C ages and calibrated dates of the analysed samples are presented in Table 1.

The first sample of Tsakali 0 (see Table 1) was chemically processed with a weak version of the VV protocol (with every step at room temperature; see the section above), preceded with overnight subsequent soakings in acetone, alcohol (2-isopropanol) and water, and followed by a thirty-minute treatment with 2.5% NaClO₂+HCl (20°C). In general, acetone and alcohol are the solvents applied to remove contamination by organic impregnates/preservatives (introduced e.g. for maintenance in a museum); however, the *tsakali* have never been maintained in such a way, so here the acetone/alcohol treatment was applied just to remove the modern fats deposited during handling by humans. Further, treatment with NaClO₂ is generally applied in the ¹⁴C dating of wood¹³ in order to remove potentially mobile fractions such as lignins, resins and waxes. In order to avoid a complete loss of the sample material, all the treatments above were applied at room temperature, and the total loss appeared small: of 14.0 mg of raw sample, as much as 8.2 mg of material ultimately remained.

The calibrated ¹⁴C date of Tsakali 0, which is the second half of the fifteenth century at the oldest, is younger than its stylistically-based association with the fourteenth century suggests (Figs 2a–b). In light of this, and of the rather small

⁷ Aghaei et al. 2023.

⁸ Oda, Nakamura and Furukawa 1998.

⁹ Goslar, Czernik and Goslar 2004.

¹⁰ According to Stuiver and Polach 1977.

¹¹ Reimer et al. 2020.

¹² Bronk Ramsey 2020.

¹³ Brock et al. 2010.

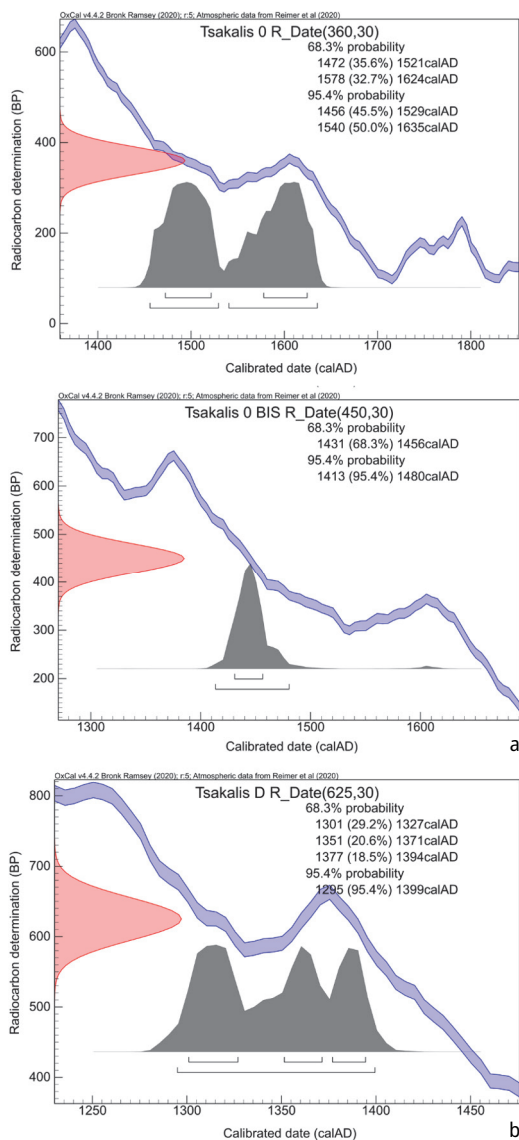
loss of material in the weak VV treatment, we decided to date another subsample (called Tsakali 0 BIS), applying a much stronger process of cellulose extraction. In detail, the sample was subsequently treated with 1M NaOH (80°C, overnight); 1M HCl (80°C, 1h); 1M NaOH (80°C, 1.5h; the step was repeated until no more colouration occurred); 1M HCl (80°C, 1h); 5% NaClO₂+HCl (pH=2, 80°C, 2h; the step was repeated until a white colour was obtained from the sample); and 5% NaClO₂ (pH=2, 20°C, 15m in an ultrasonic bath). The loss of material in this process – only 1.25 mg from the initial mass of 13.1 mg remained – was much bigger than in the weak VV attempt, so we can be sure that for Tsakali 0 BIS, the contamination potentially altering the ¹⁴C age has been removed much more effectively.

A difference between ¹⁴C ages of Tsakali 0 and Tsakali 0 BIS (360±30 BP vs 450±30 BP), significant at a level of 5%, suggests that the first dating result was slightly inaccurate due to the younger contamination not being fully removed by the weak VV processing. Nevertheless, the card Tsakali 0 appears to date from the mid fifteenth century, and is therefore younger than its stylistically-based association (Figs 2a–b).

The same process of cellulose extraction from the sample of Tsakali D had an even lower yield (0.55 mg remained from 8.4 mg of raw material); this sample was ¹⁴C dated to 625±30 BP, indicating any time within the fourteenth century. So we can be nearly sure that the two *tsakali* (0 and D) were manufactured at different times, with Tsakali 0 having been produced at least fifty years after Tsakali D (Figs 2a–b).

Table 1: Results of the radiocarbon analysis of *tsakali* paper presented in this study.

Sample name	Procedure	Raw sample (mg)	After treatment (mg)	To combustion (mg)	After combustion (mg)	Lab no. Poz-	¹⁴ C age	Calibrated date (68.3%)	Calibrated date (95.4%)
Tsakali 0	Ac/Alc + VV + bleaching	14.0	8.2	2.5	1.08	153645	360±30 BP	1472–1521 CE 1578–1624 CE	1456–1529 CE 1540–1635 CE
Tsakali 0 BIS	Ac/Alc + cellulose	13.1	1.25	1.25	0.76	162877	450±30 BP	1431–1456 CE	1413–1480 CE
Tsakali D	cellulose	8.4	0.55	0.55	0.26	167393	625±30 BP	1301–1327 CE 1351–1371 CE 1377–1394 CE	1295–1399 CE



Figs 2a–b: Results of the calibration of ^{14}C ages determined for three samples of paper from (a) Tsakali 0 (two samples) and (b) Tsakali D (one sample). The pink bell-shaped curves on the y-axes represent probability distributions of the radiocarbon age, whereas the grey shapes on the x-axes are the probability distributions of the calibrated dates. The sub-intervals making up the 68.3% and 95.5% confidence intervals of the calibrated dates are displayed in the square brackets below. The thick blue bands represent fragments of the ^{14}C calibration curve.

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.

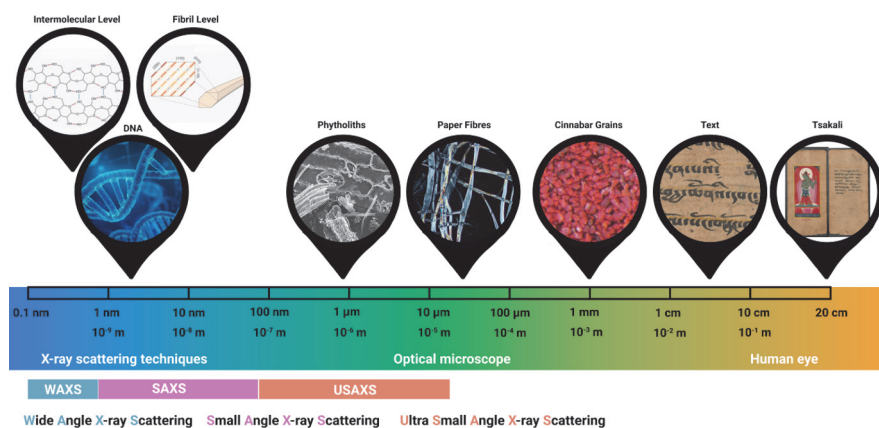


Fig. 1: The scales at which particular elements and materials of the object were examined.

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

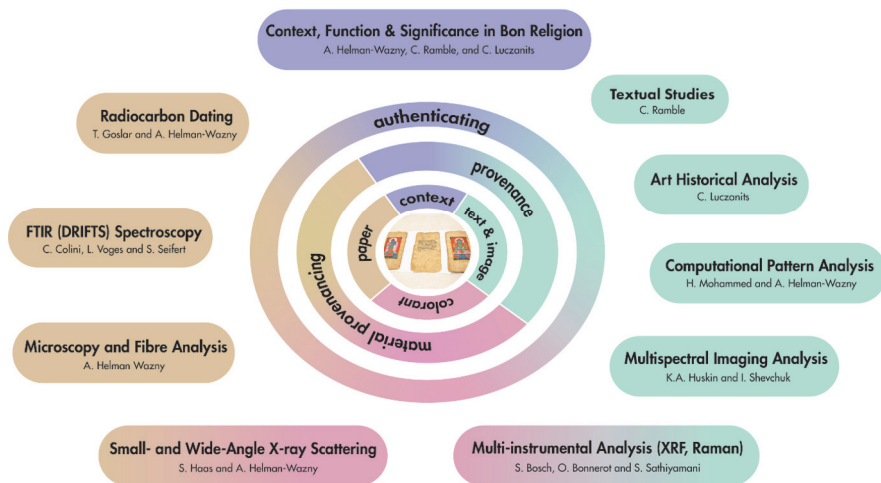


Fig. 3: Outline of the cross-disciplinary analysis of the Zhangzhung Nyengyü *tsakali* collection.

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.

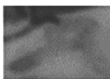
Artificial intelligence tools are most effectively used in the context of large collections, which is why this approach was appropriate for the analysis of the cards, especially since more such cards are preserved in the Triten Norbutse Monastery in Kathmandu. In the future, these may be examined by 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.

Appendix

This appendix is a handlist of the *tsakali* cards with transliterated and translated text of inscriptions. It provides Romanised transliterations and translations of all the *tsakali*. The text contains numerous contracted forms (*bskungs yig*) that are presented first in a form approximating the contraction, then expanded in parentheses, with no emendations of heterodox orthography. The text has not been edited, and only in a few cases have improved readings been suggested (in brackets, preceded by the sign <) to clarify the meaning or to justify the translation. The numbering of the *tsakali* follows the sequence applied by Yongdzin Tenzin Namdak. Each number is succeeded by the letter the *tsakali* bears on its recto side and the numerical equivalent of that letter immediately afterwards in parentheses. The fourth element is the caption under the figure on the recto side. Where the caption differs from the usual form of the name or contains extraneous material (in some captions the name is prefaced by *sras* or *de sras*, signifying '[spiritual] son [of the figure on the preceding card]', or followed by *la*, '[transmitted] to'), the more usual form of the name is also given in parentheses.

Tsakali 0

Bum pa (vase)



Paper

Woven paper with cloudy fibre distribution made of *Stellera chamaejasme* fibres

Colourants

Azurite, carbon, cinnabar, indigo, kaolinite, malachite, orpiment

Tsakali 1

1. KA (1) Ye nyid kyis ston pa (Ye nyid kyi ston pa)



Transliteration

1. ṣ// e ma ho mingon (mi mngon) dbyings nas
2. rangin (rang bzhin) spros dang bral / ye nyid ston
3. pa'i sku la gsol bas 'deb / bcudng (bcud dang)
4. ldan pa'i sloon (slob dpon) kyis / snod dang ldan pa'i
5. slobs ma la / yid ches grubs pa
6. bsnyems pa'i / lta ba phyag rgya cheon'i (chen po'i)
7. dbang bskur bas / ye thogs ma nyid kyi
8. bon sku yang myes cheon (chen po) mngon du rtogs
9. dbang thobr (thob par) gyur1 (gyur 1) / a phad / ōṃ phad /
10. hūṃ phad / yaṃ phad / raṃ phad / raṃ phad / mang phaṭ /
11. [Ṣ] phad / li phad / 'du phad / //
12. sdeb [Ṣ] brgya dang lnga bcu 4bzhi yod /

Translation

How wonderful! Praise to the body of the Primordial Teacher who is naturally free from elaborations in the unmanifest realm. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of realising the great ancestral body of the ultimate nature of phenomena that is the primordial origin itself. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution made of *Stellera chamaejasme* fibres (spiral vessels and minor woody fibres present in the pulp)

Colourants

Carbon, cinnabar, indigo, kaolinite, orpiment

Tsakali 2

2. KHA (2) Thug rtse'i ston pa (Thugs rje'i ston pa)



Transliteration

1. s e ma ho sgron ma'i snyiongs (snyings po) chu
2. zla'i tshul du bgyud / thyes (thugs rjes) ston pa'i sku
3. la gsol bas 'deb / bcudng (bcud dang) ldan pa'i
4. sloobn (slob dpon) kyis / snodng (snod dang) ldang pa'i slobs ma'i
5. la / lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang skur bas /
6. mtshan dang dpe' byad rdzogs pa nyid dong ldan /
7. thyes (thugs rjes) cheno (chen po) 'khors ('khor 'das) 2ed (2 med) 1 du rtogs pa'i
8. dbang thobr (thob par) gyur 1 / a phad / òṃ phad /
9. hūṃ phad /

Translation

How wonderful! Praise to the body of the Teacher of Compassion, who is transmitted like the essence of light, the reflection of moon on water. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, being endowed completely with the major and minor signs, may you receive the empowerment of realisation through being not separate from, but identical with, the Compassionate One and his entourage. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution made of *Stellera chamaejasme* fibres (singular fibre of silk)

Tsakali 3

3. NGA (4) Cir yang sprul pa'i ston pa



Transliteration

1. ṣ e ma ho rangin (rang bzhin) med par rmi lam
2. mdang ltar bshad (< shes) // sprul pa'i ston pa'i
3. sku la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloba dpon kyis / snodng (snod dang) ldan pa'i
5. sloba ma la / lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang
6. bskur bas / sprul pa'i sku dang ldans (ldan pas) /
7. 'gro ba tha dag 'dren pa'i dbang thobr (thob par) gyur /
8. a phad / òṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of the Manifested Teacher, who knows [existence] to be like the manifestation of a dream, with no inherent nature. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, with the manifested body may you receive the empowerment of guiding all living beings [to liberation]. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution and outer bark particles made of *Stellera chamaejasme* fibres (spiral vessels and minor woody fibres present in the pulp)

Colourants

Azurite, carbon, cinnabar, gold, hematite, indigo, kaolinite, malachite, manganite, orpiment, pararealgar

Tsakali 4

4. {CA} (5) Tshad med 'od Idan



Transliteration

1. ś e ma ho bar lha 'od gsal
2. sprul pa'i zhing 'khamś nas /
3. bsgribs med mkhyen pa'i ma rig
4. mun pa sel / tshad med thyes (thugs rje)
5. 'gro rnamś bu ltar skyobs / tshad med
6. 'od Idan sku la bstod / mkhyen
7. rtsa'i ngang nas dbang bskur byinis (byin gyis)
8. brlobś / ś na mo rigin (rig 'dzin) gshen
9. kyis bu la / bderes (bder gshegs) dgong pa'i
10. brgyud pas dbang bskur bas / sku
11. Inga lhun kyis grubs pa'i dbang
12. thobs par gyur 1 / dz+nya na si ti
13. dhe ba drang / a / ōṃ / hūṃ /

Translation

How wonderful! Praise to Öden Barma in the manifested pure realm Barlha Ösal, the paradise of the gods of clear light, who through his unsullied wisdom clears away the darkness of ignorance and protects living beings as if they were his own children. Bestow the blessings of empowerment from the state of wisdom and compassion. Hail! The mind transmission of the blessed ones having been bestowed on you, O son of the knowledge-holding priests, may you receive the empowerment of the spontaneously perfected five bodies. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution made of *Stellera chamaejasme* fibres (short fibres, more damaged)

Tsakali 5

5. NA (12) Yab 'Phrul gshen snang ldan



Transliteration

1. ś e ma ho mkha' la 'od byung
2. g.yu bya nyid du sprul / yab 'phrul
3. gshen snang ldan sku la gsol bas
4. 'deb / bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis
5. snodng (snod dang) ldan dang slob ma la / yid ches
6. grubs pa snyems pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i)
7. dbang skur bas / mkha' gsal rangin (rang bzhin)
8. rnamṣ par dag pa'i dbang thobr (thob par) gyur 1 /
9. a phad / ōṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of sPrul gshen snang ldan, who manifests in space as the turquoise bird of light itself. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of inherently pure luminous space. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution and outer bark particles made of *Stellera chamaejasme* fibres

Tsakali 6

6. CA (5) rGyud khungs kyi ston pa¹



Transliteration

1. ś e ma ho bka' rgyud lung man ngag
2. kun kyis 'byung gnas ste / rgyud khung
3. ston pa'i sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloba dpon kyis /
5. snodng (snod dang) ldan pa'i sloba ma la / lta ba
6. phyargya (phyag rgya) cheno'i (chen po'i) dbang skur bas / rgyud pa
7. bzhi dang ldan nas / rgyud lung man
8. ngag rdzogs pa'i dbang thobr (thob par) gyur 1 /
9. a phad / ōṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of the Teacher who is the origin of the lineage, the source of all the teachings of the transmitted command. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, now that you are endowed with the four lineages may you receive in full the empowerment of the transmitted teachings. *A phad / ōṃ phad / hūṃ phad /*

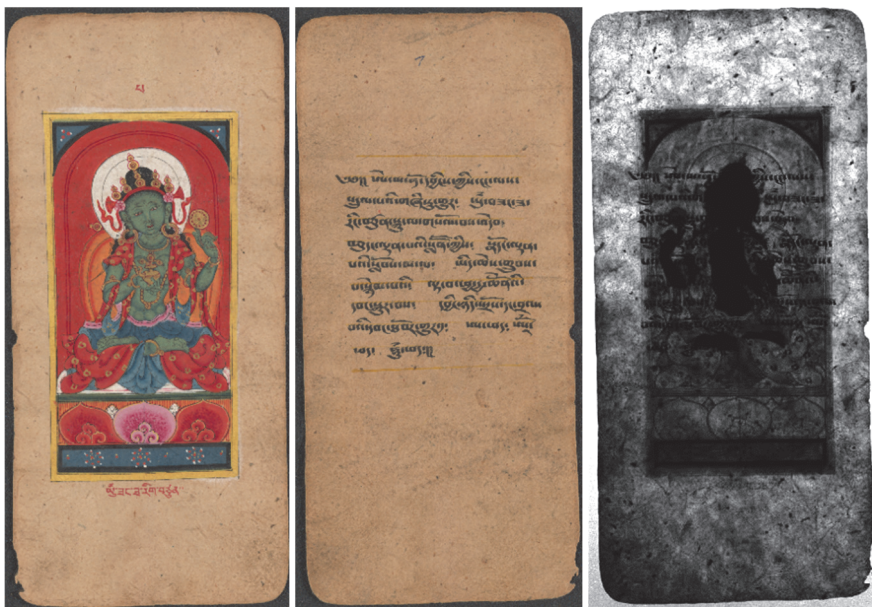
Paper

Woven paper with fibre bundles made of *Stellera chamaejasme* fibres

¹ At this point we would normally expect to find Bar snang Khu byug ('the cuckoo of the mid-air'), a divinity who is sometimes actually represented as a bird (see Karmay 1998, 4–5). Interestingly, the preceding card, no. 5, does refer to the manifestation of a 'turquoise bird' – an epithet of the cuckoo.

Tsakali 7

7. PA (13) Yum Zang za rig btsun (Yum bZang za ring btsun)



Transliteration

1. § e ma ho dbyings kyis ngang las
2. sprul pa'i gzhi ru gyur / yum bzang za
3. ring btsun sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan
5. pa'i slob ma la / yid ches grubs
6. pa snyem pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i)
7. dbang skur bas / dbying nyid spros dang bral
8. ba'i dbang thobr (thob par) gyur 1 / a phad / ḡṃ
9. phad / hūṃ phad /

Translation

How wonderful! Praise to the body of the Mother bZang za ring btsun, the base that manifested from the state of the pure dimension. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the pure dimension that is free from elaborations. *A phad / ḡṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution made of *Stellera chamaejasme* fibres (spiral vessels and minor woody fibres present in the pulp)

Tsakali 8

8. PHA (14) Sras 'Chi med gtsug phud²



Transliteration

1. š e ma ho mkha' las sprul
2. nas gzhonu'i (gzhon nu'i) sku ru sprul / 'chi med
3. gtsugd (gtsug phud) sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slon po) kyis / bsnodng (bsnod dang)
5. ldan pa'i sloba ma la / yid ches
6. grubs pa snyems pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i)
7. dbang skur bas / mkha' dbyings 2ed (med) mnyam
8. pa cheno'i (chen po'i) dbang thobr (thob par) gyur 1 / a phad /
9. òṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of 'Chi med gtsug phud, manifesting as a youth who emanated from space. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the great unity with the pure dimension of space. *A phad / òṃ phad / hūṃ phad /*

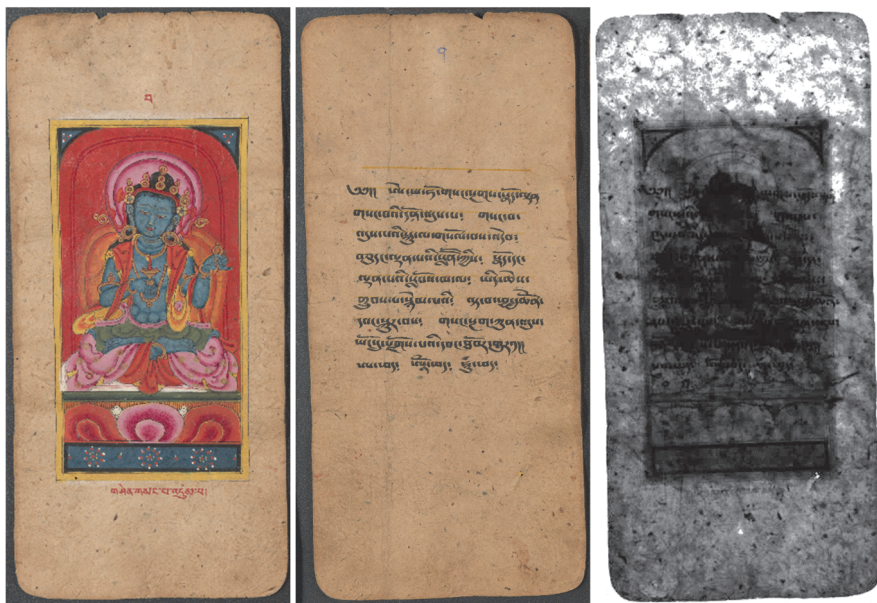
Paper

Woven paper with some fibre bundles made of *Stellera chamaejasme* fibres

² The prefix *sras* in this case signifies not only that 'Chi med gtsug phud was the spiritual son of his predecessor Yum ('the Mother') bZang za ring btsun but also her biological son.

Tsakali 9

9. BA (15) gShen gSang pa 'dus pa (gShen gSang ba 'dus pa)



Transliteration

1. § e ma ho gsang sngags snod ldan
2. gsang ba'i don 'dus pa / gsang ba
3. 'dus pa'i sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slon po) kyis / snodng (snod dang)
5. ldan pa'i sloba ma la / yid ches
6. grubs pa snyem pa'i / Ita ba phyargya (phyag rgya) cheno (chen po)
7. dbang skur bas / gsang sngag kun 'dus
8. yongsu (yongs su) rdzogs pa'i dbang thobr (thob par) gyur 1 /
9. a phad / òm phad / hūm phad /

Translation

How wonderful! Praise to the body of gSang ba 'dus pa, the vessel of the secret mantras in whom the secret meaning is gathered. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive in full the empowerment of the gathering of all secret mantras. *A phad / òm phad / hūm phad /*

Paper

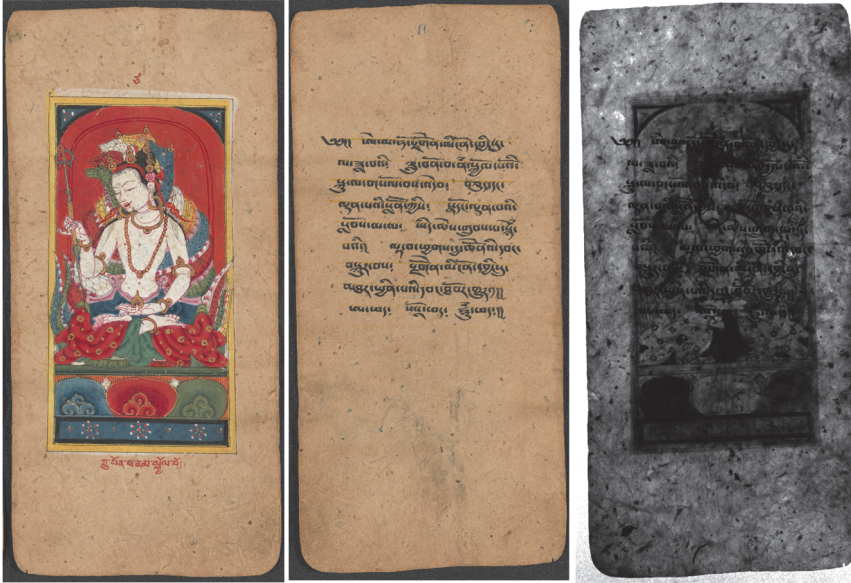
Woven paper with cloudy fibre distribution and outer bark particles made of *Stellera chamaejasme* fibres

Tsakali 10

10. [lHa bon yongs su dag pa – missing]

Tsakali 11

11. TSA (17) Klu bon Ba nam skyol po



Transliteration

1. Š e ma ho rdzogen (rdzogs chen) mingon (mi mngon) dbyingsu (dbyings su)
2. la zla ba'i / klu bon ba nam skyol po'i
3. sku la gsol bas 'deb / bcud dang
4. ldang pa'i slood (slob dpon) kyis / snodngn (snod dang) ldan pa'i
5. slobs ma la / yid ches grubs pa snyem
6. pa'i / lta ba phyags rgya cheno'i dbang
7. bskur bas / rdzogen (rdzogs chen) mingon (mi mngon) dbyingsu (dbyings su)
8. mthar phyin pa'i dbang thobr (thob par) gyur1 //
9. a phad / ōṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of Klu bon Ba nam skyol po, who passed beyond into the invisible pure dimension of the Great Perfection. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of attaining to the invisible pure dimension of the Great Perfection. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution and outer bark particles

Tsakali 12

12. TSHA (18) Mi bon Khri Ide zam bu



Transliteration

1. ṣ// e ma ho rdzoegn (rdzogs chen) semṣdi (sems nyid) ngang du
2. la zla ba'i / mi bon khri Ide zam
3. bu'i sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang)
5. ldan 'pa'i slobs ma la / yid ches
6. grubs pa bsnem pa'i / lta ba phyargya (phyag rgya)
7. cheon (chen po'i) dbang skur bas / rdzoegn (rdzogs chen)
8. semṣid (sems nyid) ngang du mngon du gyur pa'i dbang thobr (thob par)
9. gyur1 / a phad / òṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of Mi bon Khri Ide zam bu, who passed beyond into the state of the nature of the mind that is the Great Perfection. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of actually attaining the state of the nature of the mind that is the Great Perfection. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 13

13. DZA (19) Zhang zhung Ba nam skyol bo /



Transliteration

1. §// e ma ho rdzoegn (rdzogs chen) rgya mtsho'i dbyingsu (dbyings su)
2. la zla ba'i / zhang zhung ba nam skyol pa'i
3. sku la gsol bas 'deb / bcud dang
4. Idan pa'i sloon (slob dpon) kyis / snod dang Idan pa'i
5. slob ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyag rgya cheno'i (chen po'i)
7. dbang skur bas / rdzogen (rdzogs chen) rgya mtsho ltur (lta bur)
8. kha gting med pa'i dbang thobr (thob par) gyur1 (gyur 1) /
9. a phad / òṃ phad / hūṃ phad / //

Translation

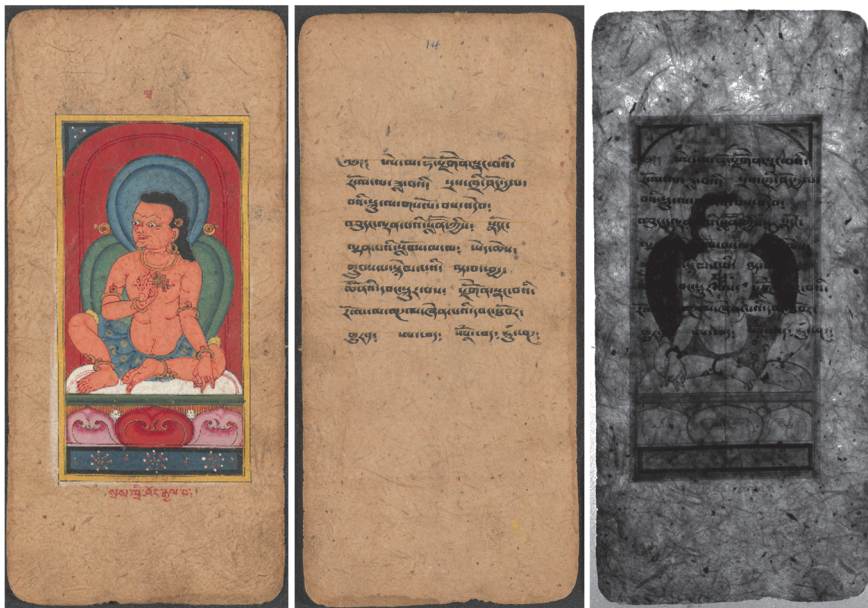
How wonderful! Praise to the body of Zhang zhung skyol pa, who passed beyond into the dimension of the ocean of the Great Perfection. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the Great Perfection that is like the unfathomable ocean. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution and outer bark particles

Tsakali 14

14. WA (20) Sras Khri shod rgyal ba



Transliteration

1. ṣ// e ma ho rdzogen (rdzogs chen) snang ba'i
2. ro la la zla ba'i / sras khri shod rgyal
3. ba'i sku la gsol bas 'deb /
4. bcud dang ldan pa'i sloon (slob dpon) kyis / snodng (snod dang)
5. ldan pa'i slobs ma la / yed ches
6. grubs pa snyem pa'i / Ita ba phygya (phyag rgya)
7. cheon'i (chen po'i) dbang skur bas / rdzogen (rdzogs chen) snang ba'i
8. ro la ma chags pa zhen pa'i dbang thobr (thob par)
9. gyur1 (gyur 1) / a phad / ḡṃ phad / hūṃ phat /

Translation

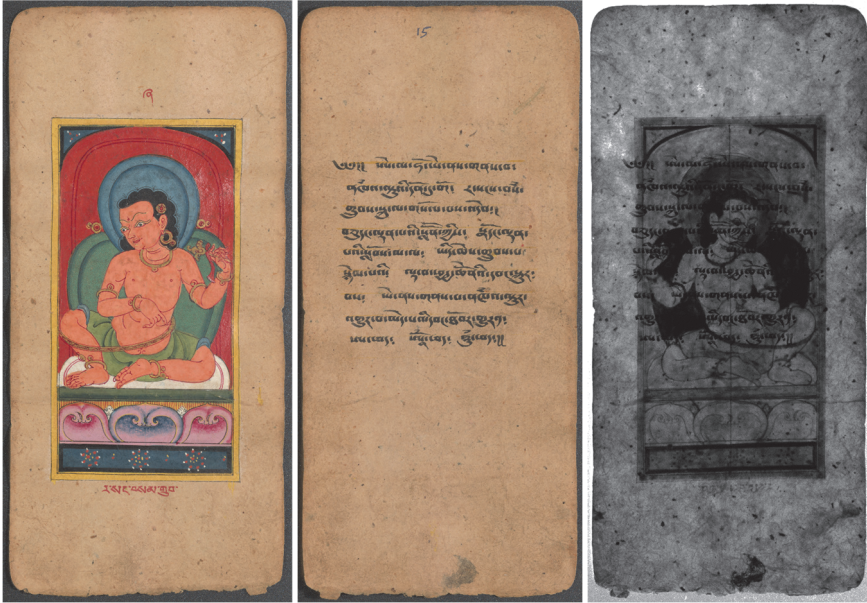
How wonderful! Praise to the body of Khri shod rgyal ba, the noble son who has passed beyond the taste of the visions of the Great Perfection! The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the determination to avoid attachment to the taste of the visions of the Great Perfection. *A phad / ḡṃ phad / hūṃ phat /*

Paper

Woven paper with many fibre bundles

Tsakali 15

15. ZHA (21) Ra sang bsam grub



Transliteration

1. §// e ma ho ye nas gnas ba
2. namkha' (nam mkha') ltu'i (lta bu'i) don du go / ra sangs bsam
3. grubs sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan
5. pa'i slob ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyargya (phyag rgya) cheon'i (chen po'i) dbang skur
7. bas / ye nas gnas ba namkha' (nam mkha') ltur (lta bur)
8. 'gyur ba med pa'i dbang thobr (thob par) gyur1 (gyur 1)
9. a phad / òṃ phad / hūṃ phad / //

Translation

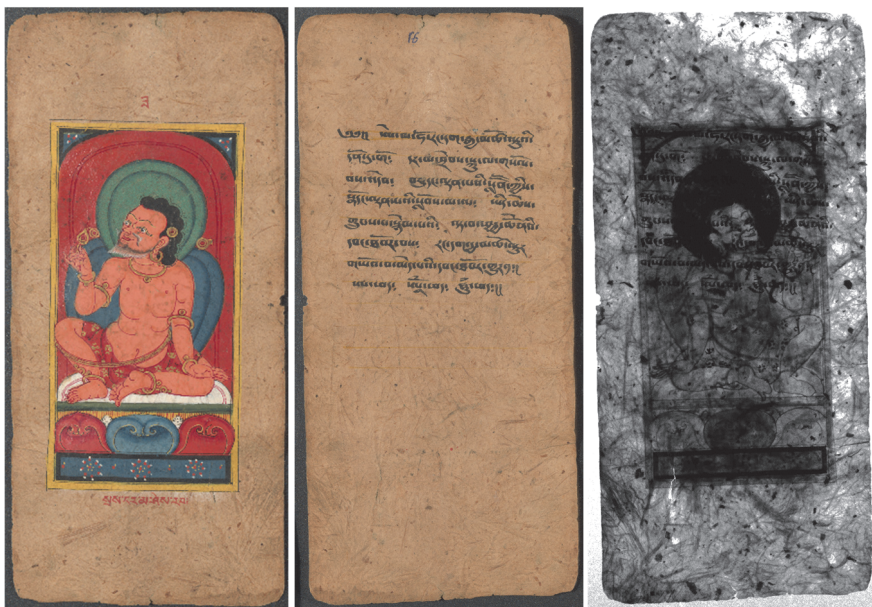
How wonderful! Praise to the body of Ra sangs bsam grub, who understood the meaning of being primordially present, like space. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of immutability that is like primordially present space. A phad / òṃ phad / hūṃ phad /

Paper

Woven paper with cloudy fibre distribution

Tsakali 16

16. ZA (22) Sras Dar ma shes rab (Dar ma shes rab)



Transliteration

1. §// e ma ho rang dag rgya mtsho ltu'i (lta bu'i)
2. don du go / dar ma shrebs (shes rab) sku la gsol
3. bas 'deb / bcud dang ldan pa'i sloon (slob dpon) kyis /
4. snodng (snod dang) ldan pa'i slob ma la / yid ches
5. grubs pa snyem pa'i / lta ba phyargya (phyag rgya) cheon'i (chen po'i)
6. dbang thobr pas / rang dag rgya mtsho ltur (lta bur)
7. g.yo ba med pa'i dbang thobr (thob par) gyur1 (gyur 1) /
8. a phad / òm phad / hūm phad //

Translation

How wonderful! Praise to the body of Dar ma shes rab, who understood the meaning that is like the intrinsically pure ocean. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of immovability that is like the intrinsically pure ocean. *A phad / òm phad / hūm phad /*

Paper

Woven paper with fibre bundles

Tsakali 17

17. 'A (23) Sras Dar ma po de la (Dar ma 'bo de)



Transliteration

1. §// e ma ho lhrubs (lhun grubs) rgyal po ltu'i (lta bu'i) don
2. du go / dar ma po de'i sku la gsol bas
3. 'deb / bcudng (bcud dang) ldan pa'i sloba dpon kyi /
4. snodng (snod dang) ldan pa'i sloba ma la / yid ches
5. grubs pa snyem pa'i / lta ba phyrgya (phyag rgya) cheon'i (chen po'i)
6. dbang skur bas / lhrubs (lhun grubs) rgyal po ltur (lta bur)
7. 'khors ('khor 'das) zil gyis gnon pa'i dbang
8. thobr (thob par) gyur¹ (gyur 1) / a phad / ōṃ phad /
9. hūṃ phad //

Translation

How wonderful! Praise to the body of Dar ma po de, who understands the meaning that is like the spontaneously perfected king! The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of overpowering samsara and nirvana like the spontaneously perfected king. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution

Tsakali 18

18. YA (24) Zhang zhung Khri 'phan la (Zhang zhung Khri 'phan)



Transliteration

1. ṣ// e ma ho 'chor med yees (ye shes)
2. gzer bu'i don du go / zhang zhung khri
3. 'phan sku la gsol bas 'deb /
4. bcud dang ldan pa'i sloon (slob dpon) kyis / snod dang
5. ldan pa'i slobs ma la / yid ches
6. grubs pa snyem pa'i / Ita ba phyrgya (phyag rgya) cheon'i (chen po'i)
7. dbang skur bas / 'chor med gzer bu
8. thebs pa'i dbang thobr (thob par) gyur1 (gyur 1) / a phad /
9. ōṃ phad / hūṃ phad //

Translation

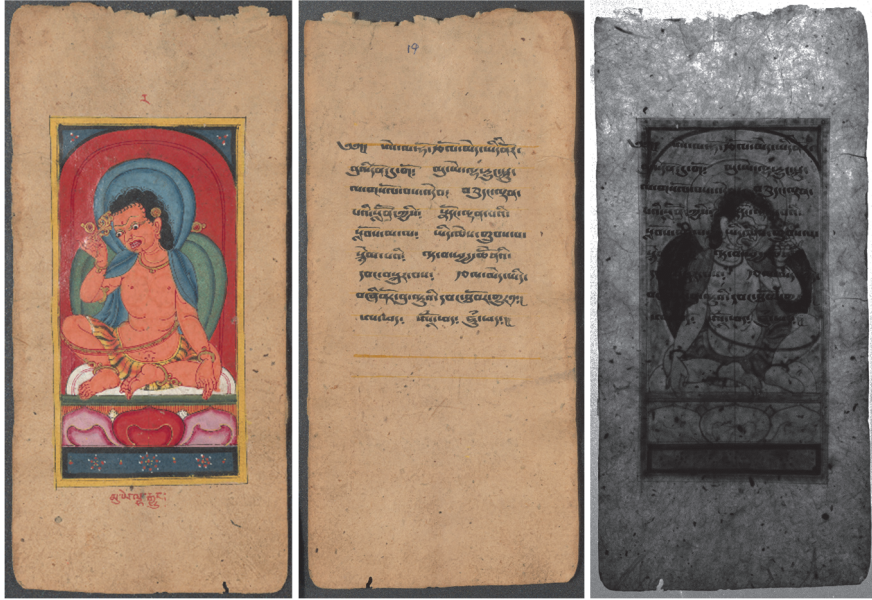
How wonderful! Praise to the body of Zhang zhung khri 'phan, who has realised how to pin down transcendent wisdom so that it does not escape! The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of driving in the nail that avoid the loss [of wisdom]. A *phad* / *ōṃ phad* / *hūṃ phad* /

Paper

Woven paper with fibre bundles

Tsakali 19

19. RA (25) Mu ye lha rgyung



Transliteration

1. §// e ma ho rtsol med yid inor (yid bzhin nor)
2. bu'i don du go / mu ye lha rgyung sku
3. la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. slob ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyrgya (phyag rgya) cheon'i (chen po'i)
7. dbang bskur bas / rtsal med yid
8. bzhinor (yid bzhin nor) bu ltu'i (lta bu'i) dbang thobr (thob par) gyur1 (gyur 1) /
9. a phad / òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Mu ye lha rgyung, who understood the meaning of the wish-fulfilling jewel of effortlessness. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment that is like the wish-fulfilling jewel of effortlessness. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution

Tsakali 20

20. LA (26) rMa gshen leg bzang (rMa gshen legs bzang)



Transliteration

1. ṣ// e ma ho skyon med metog (me tog)
2. ltu'i (lta bu'i) don du go / rma gshen legs
3. bzang sku la gsol bas 'deb / bcudng (bcud dang)
4. ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. slob ma la / lta ba phyra rgya cheon'i (chen po'i)
6. dbang skur bas / 'dam nas skyes
7. pa'i pad ma ltur (lta bur) skyon kyis ma gos
8. pa'i dbang thobr (thob par) gyur1 (gyur 1) / a phad /
9. ōṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of rMa gshen legs bzang, who understood the meaning of flower-like flawlessness. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the unsullied empowerment that is like the lotus rising from the swamp. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with many fibre bundles

Tsakali 21

21. SHA (27) Sras sTag la (sTag la)



Transliteration

1. §// e ma ho sems la skye 'gag
2. med de namkhar (nam mkhar) rtogs / sras stag lha'i
3. sku la gsol bas 'deb / bcudng (bcud dang)
4. Idan pa'i sloon (slob dpon) kyis / snod dang ldan
5. pa'i slob ma la / Ita ba phyrgya (phyag rgya) cheon (chen po)
6. yis dbang skur bas / namkha (nam mkha') ltur (Ita 'bur) skye 'gag thamd (thams cad) dang
7. bral ba'i dbang thobr (thob par) gyur1 (gyur 1) / a phad /
8. òṃ phad / hūṃ bad / //

Translation

How wonderful! Praise to the body of the noble son sTag lha, who realised the state of absence of origin and cessation as space. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of absence of all origin and cessation that is like space. A phad / òṃ phad / hūṃ phad /

Paper

Woven paper with cloudy fibre distribution

Tsakali 22

22. SA (28) Ra sangs g.yung drung



Transliteration

1. ṣ// e ma ho rang gis sems ni
2. srgyas (sangs rgyas) don la dgong / ra sangs g.yurng (g.yung drung)
3. sku la gsol bas gsdem / bcudng (bcud dang)
4. ldan pa'i slob dpon kyis / snodng (snod dang) ldan
5. pa'i slob ma la / lta ba phyrgya (phyag rgya) cheon'i (chen po'i)
6. dbang skur bas / rang sems srgyas (sangs rgyas) don du
7. thag chod pa'i dbang thobr (thob par) gyur1 (gyur 1) //
8. a phad / ōṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Ra sangs g.yung drung, who realised his own mind in the state of Buddhahood. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of resolving your own mind in the state of Buddhahood. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 23

23. HA (29) De sras g.yung 'phan (gYung 'phan)



Transliteration

1. §// e ma ho yul du [dang] shes pa 2ed (gnyis med)
2. thya (thugs) la mnga' / de sras g.yu 'phan sku
3. la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs pa bsnyem
6. pa'i / lta ba phya rgya cheon'i (chen po'i) dbang skur
7. bas / yul dang shes pa 2su (2 su) med pa'i
8. dbang thobr (thob par) gyur1 (gyur 1) / a phad / òṃ phad
9. hūṃ phad / //

Translation

How wonderful! Praise to the body of gYung 'phan, in whose mind the consciousness and its objects are united. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of non-duality of consciousness and its objects. *A phad / òṃ phad / hūṃ phad /*

Paper

Laid paper with cloudy fibre distribution

Tsakali 24

24. A (30) dGe 'par don grub (dGe 'phar don grub)



Transliteration

1. ṣ// e ma ho rang sems ya nas
2. srgyas (sangs rgyas) don la dgong / dge' 'phar don
3. grubs sku la gsol bas 'deb
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan
5. pa'i slob ma la / yid ches grubs
6. pa snyems pa'i lta ba phyrgya (phyag rgya) cheon'i (chen po'i)
7. dbang skur bas / rang sems ya nas srgyas (sangs rgyas)
8. mthar phyin pa'i dbang thobr (thob par) gyur1 (gyur 1) //
9. a phad / ōṃ phad / hūṃ phad //

Translation

How wonderful! Praise to the body of dGe 'phar don grub, who ponders on the meaning of one's own mind being primordially enlightened. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of your own mind being primordially fully enlightened. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 25

25. KI (31) De sras dge 'phan (dGe 'phan)



Transliteration

1. §// e ma ho ma bcos ngang grol
2. dgong pa'i thyas (thugs) la mnga' / de sras dge'
3. 'phan sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan
5. pa'i slob ma la / yid ches grubs
6. pa snyem pa'i / lta ba phyrgya (phyag rgya) cheon'i (chen po'i) dbang
7. bskur bas / ma bcas dgong pa ngang gis
8. grol ba'i dbang thobr (thob par) gyur1 (gyur 1) / a phad /
9. òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of dGe 'phan, who was endowed with the realisation of the liberation in the uncontrived state. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of liberation in the state of uncontrived realisation. *A phad / òṃ phad / hūṃ phad /*

Paper

Laid paper with cloudy fibre distribution

Colourants

Aniline black (black ink from recto), azurite, carbon, cinnabar, gold, indigo, kaolinite, malachite, orpiment

Tsakali 26

26. KHI (32) De sras dge' rgyas (dGe rgyas)



Transliteration

1. §// e ma ho rang gis sems ni
2. srgyas (sangs rgyas) don la dgong / de sras dge rgyas
3. sku la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs pa snyem pa'i /
6. lta ba phyrgya (phyag rgya) cheon'i (chen po'i) dbang bskur bas /
7. byungbs (byang chubs) kyis srgyas (sangs rgyas) kyis dgong pa mngon du
8. gyur pa'i dbang thobr gyur1 / a phad /
9. òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of dGe rgyas, who conceived his mind as enlightened. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of actually attaining the thought of enlightened Buddhahood. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 27

27. GI (33) Zhang zhung rnam rgyal



Transliteration

1. §// e ma ho gnas lugs dgong
2. rtogs cang kyis rnyed / zhang zhung rnam
3. rgyal sku la gsol bas 'deb / bcudng (bcud dang)
4. ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. slob ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyrgya (phyag rgya) cheon'i (chen po'i) dbang
7. bskur bas / gnas lugis (lug gis) dgong pa
8. cang kyis rnyed pa'i dbang thobr (thob par) gyur1 (gyur 1)
9. a phad / òṃ phad / hūṃ phad //

Translation

How wonderful! Praise to the body of Zhangzhung rNam rgyal, who effortlessly realised the natural state. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of effortlessly attaining the natural state. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 28

28. NGI (34) Mu rgyung dkar po



Transliteration

1. ṣ// e ma ho sems kyis mtshanid (mtshan nyid)
2. ci ltar yin par go / mu rgyung dkar po'i
3. sku la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs la snyems
6. pa'i / lta ba phyrgya (phyag rgya) cheon'i (chen po'i) dbang skur
7. bas / sems kyis mtshanid (mtshan nyid) ctir (ci ltar) yin
8. pa'i dbang thobr (thob par) gyur1 (gyur 1) / a phad /
9. ṁ phad / hūṁ phad //

Translation

How wonderful! Praise to the body of Mu rgyung dkar po, who understands what the characteristics of the mind are like. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of what the characteristics of the mind are like. *A phad / ṁ phad / hūṁ phad /*

Paper

Woven paper with fibre bundles

Tsakali 29

29. CI (35) Hor ti chen po



Transliteration

1. §// e ma ho mnyams pa'i ngang la
2. ci mi dmig / hor ti cheno'i (chen po'i) sku la
3. gsol bas 'deb / bcudng (bcud dang) ldan pa'i
4. sloon (slob dpon) kyis bsnodng (bsnod dang) ldan pa'i slob
5. ma la / yid ches grubs pa snyem
6. pa'i / lta ba phyrgya (phyag rgya) cheon'i (chen po'i) dbang skur bas /
7. mnyams pa nyid kyis ngang la cir yang mi
8. dmig [mi dgag] pa'i dbang thobr (thob par) gyur 1 / a phad
9. òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Hor ti chen po, who did not conceive of anything in the state of equanimity. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of not conceiving of anything in the state of equanimity. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 30

30. CHI (36) Don kun grub pa



Transliteration

1. s// e ma ho lta ba dbu rgyan dagis (dag gis)
2. la zla ba'i / don kun grubs pa'i sku la
3. gsol bas 'deb / bcudng (bcud dang) ldan pa'i
4. sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slobs ma la /
5. yid ches grubs pa nyem pa'i / lta ba
6. phyagrya (phyag rgya) cheon'i (chen po'i) dbang skur bas / lta ba mtha'
7. dang bral ba'i dbang thobr (thob par) gyur 1 /
8. a phad / òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Don kun grub pa, who surpasses the crowning ornaments of view. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the view that is free of extremes. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 31

31. JI (37) Ra sangs 'phan rgyal



Transliteration

1. §// e ma ho sgoms pa'i dbu rgyan
2. dagis (dag gis) la zla / ra sangs 'phan rgyal
3. sku la gsol ba 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs pa snyem
6. pa'i / phyagrya (phyag rgya) cheon'i (chen po'i) dbang bskur
7. bas / sgoms pa dmig gtad dang bral
8. ba'i thobr (thob par) gyur 1 / a phad / òṃ phad /
9. hūṃ phad / // //

Translation

How wonderful! Praise to the body of Ra sangs 'phan rgyal, who surpasses the crowning ornaments of meditation. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of meditation without object. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 32

32. NYI (38) Ku rib gsas rga (Gu rib gsas dga')



Transliteration

1. §// e ma ho spyod pa'i dbu rgyan
2. dagis (dag gis) ro snyoms mdzad / gu rib gsas
3. dga'i sku la gsol ba 'deb / bcudng (bcud dang)
4. ldang pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. slobs ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang
7. bskur bas / spyod pa shugs 'byung grol
8. rang sar grol ba'i dbang thobr (thob par) gyur 1 / //
9. a phad / òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Gu rib gsas dga', who performed, without discrimination, the crown-ing jewel of conduct. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of self-liberation of spontaneously-occurring conduct. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 33

33. TI (39) Zla ba rgyal mtshan



Transliteration

1. §// e ma ho 'bru'i ('bras bu'i) dbu rgyan dagi (dag gi)
2. tshad 'dzin pa'i / zla ba rgyal^n (rgyal mtshan) sku la
3. gsol bas 'deb / bcudng (bcud dang) ldan p'ai
4. sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob ma
5. la / yid ches grubs pa snyem pa'i
6. lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang skur bas / //
7. 'brus ('bras bus) mthar phyin re dog bral pa'i
8. dbang thobr (thob par) gyur 1 / a phad / òṃ phad /
9. hūṃ phad / //

Translation

How wonderful! Praise to the body of Zla ba rgyal mtshan, who accomplished the crowning jewel of the view. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the completion of the goal without hope or fear. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 34

34. THI (40) Ta pi hri tsa



Transliteration

1. ṣ// e ma ho bzhon nur sku sprul
2. las can byin gyis brlobs / ta pi ri tsa'i
3. sku la gsol bas 'deb / bcudang (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs pa snyem pa'i
6. lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang skur bas /
7. zag bcas phuon (phung po) kun [bzang] gi skur grol nas /
8. bdagzhan (bdag gzhan) rgyud grol smin pa'i dbang thobr (thob par)
9. gyur 1 / a phad / ḡṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Ta pi hri tsa, blessed with the karmic benefit of having the manifested body of a youth, who accomplished the crowning jewel of the view. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, your impure body having been liberated as the body of Kun tu bzang po, may you receive the empowerment of the maturation of the liberation of your own and others' mental continuum. *A phad / ḡṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution

Tsakali 35

35. DI (41) sNang bzher lod po



Transliteration

1. S// e ma ho bdag 'dzin spang pas
2. dgra 3 rang sar dag / snang bzher lod po
3. yis sku gsol bas 'deb / bcudng (bcud dang)
4. ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. slob ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyra rgya cheno'i (chen po'i) dbang
7. skur bas / bdag 'dzin spang nas
8. dgra 3 rang sar dag pa'i dbang thobr (thob par)
9. gyur 1 / a phad / ōṃ phad / hūṃ phad / //

Translation

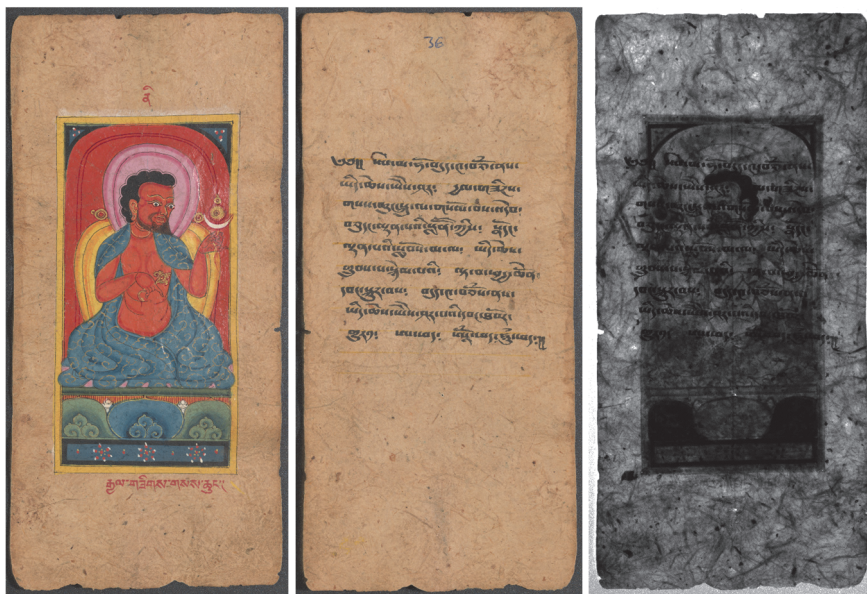
How wonderful! Praise to the body of sNang bzher lod po who, having abandoned self-grasping, naturally purified the three [external, internal and secret] enemies. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, after abandoning self-grasping may you receive the empowerment of naturally purifying the three enemies. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 36

36. NI (42) rGyal gzigs gsas chung



Transliteration

1. ṣ// e ma ho bdud 4 bcom nas
2. yid ches yees (ye shes) shar / rgyal gzigs
3. gsas chung sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang)
5. ldan pa'i slob ma la / yid ches
6. grubs pa snyem pa'i / Ita ba phyargya (phyag rgya) cheon (chen po)
7. dbang skur bas / bdud 4 bcoms nas
8. yid ches yees shar pa'i dbang thobr (thob par)
9. gyur 1 / a phad / ṍṁ phad / hūṁ phad / //

Translation

How wonderful! Praise to the body of rGyal gzigs gsas chung, in whom the wisdom of confidence arose after he had overcome the four Maras. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, having overcome the four Maras may you receive the empowerment of the wisdom of confidence. *A phad / ṍṁ phad / hūṁ phad /*

Paper

Woven paper with fibre bundles

Tsakali 37

37. PI (43) dMu' gshen tso ge (dMu gshen tso ge)



Transliteration

1. S// e ma ho semsid (sems nyid) grol [ba] zhob (< thob) pa'i
2. gzi' mdang can / dmu shyen (gshen) tso ge'i
3. sku la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs pa snyems
6. pa'i / lta ba phya rgya cheno'i (chen po'i) dbang thobr (thob par)
7. gyur 1 / snang stong dngos med rtags chadng (chad dang)
8. bral ba'i dbang thobr (thob par) gyur 1 // a phad /
9. òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of dMu gshen tso ge, who had the radiance of having achieved the liberation of the nature of the mind. May the disciple who is the vessel receive from the master who has the elixir the empowerment of the great seal of the view that has been realised with great confidence; may you receive the empowerment of the realisation of the non-substantiality of appearance and emptiness, and free from [the extremes of] eternalism and nihilism. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 38

38. PHI (44) dMu gshen tso stang



Transliteration

1. 5// e ma ho bdud pa lnga grol
2. lam kyis thoem (the tshom) bsal / dmu shyen (gshen) tso
3. stang sku la gsol bas 'deb / bcudang (bcud dang)
4. ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. sloba ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyargya (phyag rgya) cheno'i dbang
7. skur bas / bdud pa lnga grol bas
8. lam kyis thoem (< them) kyi spros pa dang bral
9. ba'i dbang thobr (thob par) gyur 1 / a phad /
10. om phad / hum phad / //

Translation

How wonderful! Praise to the body of dMu gshen tso stang, who was liberated from the five Maras and cleared his doubts about the path. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, having been liberated from the five Maras may you receive the empowerment of freedom from the elaborations of doubt about the path. *A phad / om phad / hum phad /*

Paper

Woven paper with fibre bundles

Tsakali 39

39. BI (45) Sho gram chen po



Transliteration

1. §// e ma ho bonid (bon nyid) gnas lugs
2. lhun kyis grubs / shod kram cheno'i (chen po'i)
3. sku la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i ldan
5. pa'i slob ma la / yid ches grubs
6. pa snyems pa'i / lta ba phyra rgya cheno'i (chen po'i)
7. dbang skur bas / bonid (bon nyid) yees (ye shes) kyis gnas
8. lugs lhunis (lhun gyis) grubs pa'i dbang thobr (thob par)
9. gyur 1 / a phad / ōṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Shod kram chen po, who spontaneously achieved the natural state of the ultimate nature of phenomena. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of spontaneously achieving the natural state of the wisdom of the ultimate nature of phenomena! *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 40

40. MI (46) rGyal ba blo gros



Transliteration

1. §// e ma ho thiges (thig les) bcu 2
2. mtha' dbus med par spro / rgyal ba blo
3. gros sku la gsol bas 'deb / bcudng (bcud dang)
4. ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. slobs ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyargya (phyag rgya) cheno'i dbang
7. bskur bas / thiges (thig les) bcu 2 mtha'
8. dbus med par spro ba'i dbang thobr (thob par)
9. gyur 1 / a phad / öm phad / hūm phad / //

Translation

How wonderful! Praise to the body of rGyal ba blo gros, who emanated the twelve luminous spheres at the limits and in the centre. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of emanating the twelve luminous spheres at the limits and in the centre! *A phad / öm phad / hūm phad /*

Paper

Woven paper with fibre bundles

Tsakali 41

41. Missing

Tsakali 42

42. TSHI (48) Gu ge blo ldan



Transliteration

1. S// e ma ho sdul (sdug bsngal) rang grol bdeen (bde chen)
2. rgyud la shar / gu ge blo ldan sku la
3. gsol bas 'deb / bcudng (bcud dang) ldan pa'i
4. sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slobs ma
5. la / yid ches grubs pa snyem pa'i
6. Ita ba phyra rgya cheno'i dbang skur bas /
7. sdul (sdug bsngal) rang grol bdeen (bde chen) rgyud la shar ba'i
8. dbang thobr (thob par) gyur1 / a phad / òṃ phad /
9. hūṃ phad / //

Translation

How wonderful! Praise to the body of Gu ge blo ldan, in whose mental continuum the great bliss of self-liberation arose. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the great bliss of self-liberation arising in your mental continuum! *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 43

43. DZI (49) Bu rang kun dga' (Pu hrang kun dga' ring mo)



Transliteration

1. §// e ma ho sbyang rtogs grol
2. bas gnas lugs mngon du gyur /
3. pu rang kun dga'i sku la gsol bas
4. 'deb / bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis
5. snod dang ldan pa'i slobs ma la /
6. Ita ba phyra rgya cheno'i (chen po'i) dbang skur bas /
7. sbyang stobs grol bas gnas lugs
8. mngon du gyur pa'i dbang thobr gyur1 /
9. a phad / ōṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Pu rang kun dga', in whom the natural state became apparent after training, realisation and liberation. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the natural state becoming apparent after training, realisation and liberation! *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 44

44. WI (50) rNal 'byor gsaṃ mchog



Transliteration

1. S// e ma ho shugs 'byung gnyugs
2. mar mthar thugs rang sa zin / rnoḷr (rnal 'byor)
3. gsaṃ mchog sku la gsol bas
4. 'debs / bcudng ldang pa'i sloon (slob dpon) kyis
5. snodng (snod dang) ldan pa'i slob ma la / yid ches
6. grubs pa snyems pa'i / lta ba phyargya cheno'i (chen po'i)
7. dbang skur bas / shugs 'byung gnyugs
8. ma rang sa zin pa'i dbang thobr (thob par) gyur 1 /
9. a phad / ḍṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of rNal 'byor gsaṃ mchog, who held the ultimate natural place of the spontaneously arising natural state. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of holding the natural place of the spontaneously arising natural state! *A phad / ḍṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 45

45. ZHI (51) Khyung 'byid mu thur



Transliteration

1. §// e ma ho bskyed rdzogs mthar
2. phyin luseṃs (lus sems) lha skur grubs / khyung byid
3. mu thur sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan
5. pa'i slob ma la / yid ches grubs
6. pa snyems pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang
7. skur bas / skyed rdzogs mthar phyin
8. luseṃs (lus sems) lha skur grubs pa'i dbang thobr (thob par)
9. gyur 1 / a phad / ṓṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of Khyung byid mu thur, who achieved a divine form for his body and mind as the accomplishment of generation and completion. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of achieving a divine form for your body and mind as the accomplishment of generation and completion. *A phad / ṓṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 46

46. ZI (52) bDe ba ring mo



Transliteration

1. §// e ma ho cig chod dgong pas
2. bonid (bon nyid) ma dang mjal / bde ba ring mo'i
3. sku la gsol ba 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs pa snyem
6. pa'i / lta ba phyargya (chen po'i) dbang skur bas /
7. 1 chod dgongs pa bonid (bon nyid) ma dang mjal
8. ba'i dbang thobr (thob par) gyur 1 / a phad /
9. òṃ phad / hūṃ phad / /

Translation

How wonderful! Praise to bDe ba ring mo who, with his decisive intention, encountered the ultimate nature of phenomena like [the lost child] rediscovering its mother. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of encountering the ultimate nature of phenomena like [the lost child] rediscovering its mother. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 47

47. 'I (53) rTog med zhig po (Rong rTog med zhig po)



Transliteration

1. ṣ// e ma ho rang 'byung rang shar 'khor ('khor 'das)
2. rang sar grol / rtogs med zhigs po'i
3. sku la gsol bas 'deb / bcudng (bcud dang) ldan
4. pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slob
5. ma la / yid ches grubs pa snyem ba'i
6. Ita ba phyargya (phyag rgya) cheno'i (chen po'i) dbang skur bas
7. rang 'byung rang shar rang khors ('khor bcas) rang sar grol
8. ba'i dbang thobr (thob par) gyur 1 // a phad /
9. ōṃ phad / hūṃ phad //

Translation

How wonderful! Praise to the body of rTog med zhig po, who achieved liberation from samsara and nirvana spontaneously, in his own nature. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of achieving liberation from samsara and nirvana spontaneously, in your own nature. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 48

48. YI (54) lHun grub mu thur



Transliteration

1. §// e ma ho skabs don bcu2
2. dgong pa'i sgros 'dogs gcod /
3. lhrubs (lhun grubs) mu thur sku la gsol bas
4. 'deb / bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis
5. snodng (snod dang) ldan pa'i slobs ma la / yid
6. ches grubs pa snyem pa'i / lta ba phyargya (phyag rgya)
7. cheno'i (chen po'i) dbang skur bas / dgong pa'i
8. gdang 4 sgros 'dogs chod pa'i dbang
9. thobr (thob par) gyur 1 / // a phad / òṃ phad /
10. hūṃ phad / // // //

Translation

How wonderful! Praise to the body of lHun grub mu thur, who, having realised the twelve sections, cut off misperceptions. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of cutting off the four misperceptions of the mind through the four confidences. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 49

49. RI (55) Bla ma gshen rgyal gShen rgyal



Transliteration

1. §// e ma ho {dgong pa'i gdang 4
2. sems kyis sgros 'dog chod} // bla ma
3. shyen (gshen) rgyal sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang)
5. ldan pa'i slobs ma la / yid ches
6. grubs pa snyem pa'i / lta ba phyargya (phyag rgya)
7. cheno'i (chen po'i) dbang skur pas / {dgong pa'i
8. gdang 4 sgros 'dogs chodba'i (chod pa'i)}
9. dbang thobr (thob par gyur 1) / // a phad / òṃ phad /
10. hūṃ phad / //

Translation

How wonderful! Praise to the body of Bla ma gshan rgyal who, through the four confidences in his intention, cut off mental misperceptions. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of cutting off the four misperceptions of the mind through the four confidences. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 50

50. SHI (57) rNgos grub rgyal mtshan (dNgos grub rgyal mtshan)



Transliteration

1. §// e ma ho gdam pa'i snod rtags
2. thamd tshang pa'i gnas / dngos grubs
3. rgyal^n sku la gsol bas 'deb/
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang)
5. ldan pa'i slob ma la / yid ches
6. grubs pa snyem pa'i / lta ba phyargya (phyag rgya)
7. cheno'i (chen po'i) dbang skur pas / gdam pa'i
8. dbang thobr (thob par) gyur 1 // a phad / òm phad /
9. hūm phad //

Translation

How wonderful! Praise to the body of dNgos grub rgyal mtshan, in whom the signs of being a chosen vessel were complete. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of being chosen. *A phad / òm phad / hūm phad /*

Paper

Woven paper with fibre bundles

Tsakali 51

51. SI (58) Bla ma kun 'dul ('Or sgom kun 'dul)



Transliteration

1. §// e ma ho mi brjed gzung thobs
2. mngon shes rtsal dang ldan / bla ma kun
3. 'dul sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang)
5. ldan pa'i slob ma la / yid ches
6. grubs pa snyem pa'i / Ita ba phyargya (phyag rgya)
7. cheno'i (chen po'i) dbang thobr (thob par) gyur 1 / a phad /
8. òṃ phad / hūṃ phad //

Translation

Praise to the body of Bla ma kun 'dul, who is endowed with the capacity for clairvoyance having attained the power of memorisation. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of ... *(a section of text appears to have been omitted, probably as the result of eyeskip).*

Paper

Woven paper with fibre bundles

Tsakali 52

52. HI (59) Yang ston chen po (Ya ngal Shes rab rgyal mtshan)



Transliteration

1. Ṣ// e ma ho sprul pa'i sku'i
2. bka' drin yong la 'jogs / yang
3. ston cheno'i (chen po'i) sku la gsol bas
4. 'deb / bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis /
5. snodng (snod dang) ldan pa'i slob ma la / yid ches
6. grub pa snyem pa'i / lta ba phyargya (phyag rgya)
7. cheno'i (chen po'i) dbang skur bas / sprul sku'i
8. sku ltar bka' drin yong la 'jogs
9. pa'i dbang thobr (thob par) gyur 1 / a phad /
10. òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of the Great Ya ngal Teacher, thoroughly perfect kindness of the manifested body. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of complete kindness like the manifested body. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 53

53. I (60) Dam pa 'bum rje (Dam pa 'bum rje 'od)



Transliteration

1. s// e ma ho bka' rgyud rgya'
2. mtsho'i bdudi (bdud rtsi) bcu' du rol / dam pa 'bum
3. rje'i sku la gsol bas 'deb / bcudng (bcud dang)
4. ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i
5. slobs ma la / yid ches grubs pa
6. snyem pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang
7. bskur bas / bka' rgyud bduid'i (bdud rtsi'i) rgya
8. mtsho ltur (lta bur) bcud la rol pa'i dbang
9. thobr (thob par) gyur 1 // a phad / òṃ phad /
10. hūṃ phad / ///

Translation

How wonderful! Praise to the body of Dam pa 'bum rje, who enjoys the nectar of the ocean of the transmitted teachings. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of enjoying the nectar that is like the ocean of the nectar of the transmitted teachings. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 54

54. KU (61) bKra shis rgyal mtshan ('Gro mgon Klu brag pa bKra shis rgyal mtshan)



Transliteration

1. §// e ma ho logs pa'i chroul (cho 'phrul) dgong
2. pa'i rtsal du shar / bkris (bkra shis) rgyal^n (rgyal mtshan) sku la
3. gsol bas 'deb / bcudng (bcud dang) ldan pa'i
4. sloon (slob dpon) kyis / snodng (snod dang) ldan pa'i slobs ma
5. la / yid ches grubs pa snyem pa'i
6. Ita ba phyargya (phyag rgya) cheno'i (chen po'i) dbang skur bas /
7. log pa'i chroul (cho 'phrul) dgong pa'i rtsal du
8. shar ba'i dbang thobr (thob par) gyur 1 / a phad /
9. òṃ phad / hūṃ phad / //

Translation

How wonderful! Praise to the body of bKra shis rgyal mtshan, in the power of whose mind there arose erroneous magical displays. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of erroneous magical displays arising in the power of your mind.
A phad / òṃ phad / hūṃ phad /

Paper

Woven paper with fibre bundles

Tsakali 55

55. KHU (62) Ye shes rgyal mtshan



Transliteration

1. ṣ// e ma ho nga bdag ming' (mi mnga') mnyamṣ
2. pa'i ngang la bzhugs / rtogs ldan
3. yeēs (ye shes) rgyal^n (rgyal mtshan) sku la gsol bas'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan
5. pa'i slobṣ ma la / yid ches grubs ba
6. snyems pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang
7. bskur bas / nga bdag mi mnga' mnyamṣ
8. pa'i ngang dang ldan pa'i dbang thobr (thob par) gyur 1 /
9. a phad / ṁ phad / hūṁ phad / //

Translation

How wonderful! Praise to the bod of rTogs ldan ye shes rgyal mtshan, who abided in the state of selfless harmony. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of being in the state of selfless harmony. *A phad / ṁ phad / hūṁ phad /*

Paper

Woven paper with fibre bundles

Tsakali 56

56. GU (63) rGyal mtshan rin chen



Transliteration

1. §// e ma ho don kyis dgong pa ma bcos
2. lhru'is (lhun gyis) grubs / rgyal^n (rgyal mtshan) rien (rin chen) sku la gsol
3. ba 'debs / bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis
4. snodng (snod dang) ldan pa'i slob ma la / yid
5. ches grubs pa snyem pa'i / lta ba phyargya (phyag rgya)
6. cheno'i (chen po'i) dbang skur bas / don kyis dgongs
7. pa ma bcos lhun kyis grubs pa'i dbang
8. thobr (thob par) gyur 1 / a phad / òṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of rGyal mtshan rin chen, who spontaneously accomplished the uncontrived ultimate realisation. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of accomplishing the uncontrived ultimate realisation. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution and some fibre bundles

Tsakali 57

57. NGU (64) Dad pa shes rab Ngang pa shes rab



Transliteration

1. §// e ma ho las 'phro sad cing rtul
2. shugs spyod dang ldan / rtogs ldan
3. dad pa shrebs (shes rabs) sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang) ldan
5. pa'i slob ma la / yid ches grubs
6. pa snyems pa'i / lta ba phyargya (phyag rgya) cheno'i (chen po'i) dbang
7. bskur bas / rgyu med dngos med mtha'
8. dang bral ba'i dbang thobr (thob par) gyur 1 //
9. a phad / òṃ phad / hūṃ phad /

Translation

How wonderful! Praise to the body of rTogs ldan dad pa shes rab, who was endowed with the awakening of residual karma and with the performance of austerities. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of freedom from extremes without cause or substance. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali 58

58. CHU (65) Bla ma rgyal mtshan



Transliteration

1. S// e ma ho rang rigs rang shar 'gro
2. don phyogs med mdzad / rang grol bla ma
3. rgyal^n (rgyal mtshan) sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i sloon (slob dpon) kyis / snodng (snod dang)
5. ldan pa'i slob ma la / yid ches
6. grubs pa snyems pa'i / lta ba phyargya (phyag rgya)
7. cheno'i (chen po'i) dbang bskur bas / rang rigs
8. rang shar 'gro don {rgya} phyogs med mdzad
9. pa'i dbang thobr (thob par) gyur 1 // a phad /
10. òṃ phad / hūṃ phad / // //

Translation

How wonderful! Praise to the body of Rang grol bla ma rgyal mtshan, who acted with impartiality, naturally and spontaneously, for the sake of living beings. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of acting with impartiality, naturally and spontaneously, for the sake of living beings. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali A

A. {NGA} (4) Zhing Inga gtso' bo



Transliteration

1. §// e ma ho / zhings 'kham
2. rnamr (rnam par) dag pa'i phrong (pho brang) nas / zhing Inga'i
3. gtsoo (gtso bo) yees (ye shes) lha Inga'i sku / dug
4. Inga rnam dag rgyal ba rig Inga la /
5. sku Inga rnam dag rdzogs pa'i sku la
6. bstod / rnam dag ngang nas dbang
7. bkur byin kyis brlobs / na mo
8. rigin (rig 'dzin) gshen kyis bu la / bdeers (bder gshegs)
9. brgyud pas dbang bskur bas / sku Inga
10. lhun kyis grubs pa'i dbang thobs
11. par gyur cig / dz+nya na si ti dhe ba
12. drang / a / òṃ / hūṃ //

Translation

How wonderful! From the palace of the completely pure realm are the bodies of the five wisdom divinities, the heads of the five Buddha fields. Homage to the five Buddha families of the five purified poisons, and the five purified bodies that are the five bodies of perfection. Bestow your blessings with empowerment from the state of complete purity. Hail! The empowerments of the lineage of blessed ones having bestowed on you, O son of the knowledge-holding *gshen*, may you receive the empowerment of the spontaneously arising five bodies. *A phad / òṃ phad / hūṃ phad /*

Paper

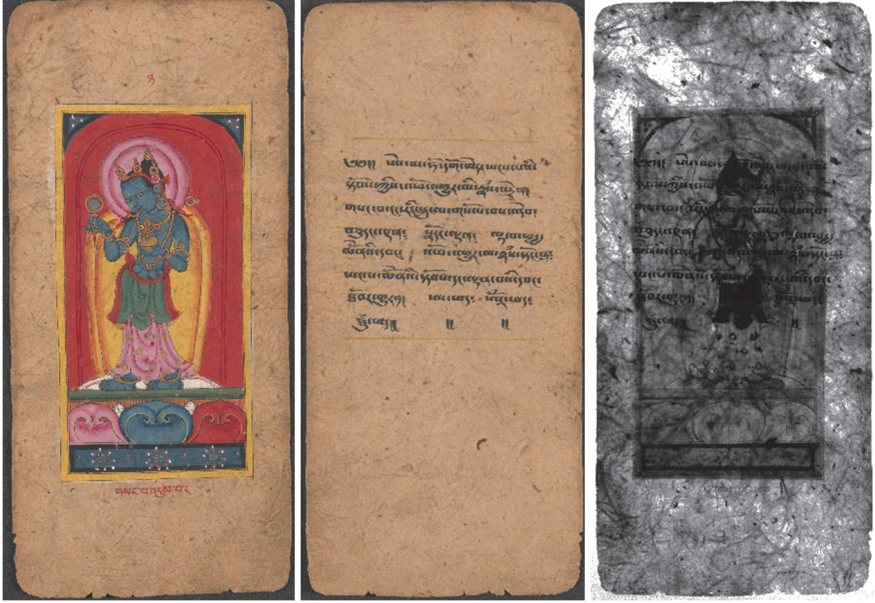
Woven paper with cloudy fibre distribution and outer bark particles

Colourants

Aniline black (black ink from recto), carbon, cinnabar, indigo, kaolinite, orpiment

Tsakali B

B. NYA (8) gSang ba 'dus pa



Transliteration

1. §// e ma ho dog med yangs pa'i
2. stobs kyis 'pho 'gyur mi rnamś 'dren
3. gsang ba ngang ring sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan =/ snodng (snod dang) ldan =/ lta ba phyargya (phyag rgya)
5. cheno'i (chen po'i) dbang =/ 'pho 'gyur ma rnamś stong nas /
6. yang pa cheno'i (chen po'i) stobs dang ldan pa'i dbang
7. thobr (thob par) gyur 1 / a phad / ōṃ phad /
8. hūṃ phad / // //

Translation

How wonderful! Homage to the body of gSang ba ngang ring, who guides transmigrating humans with the power of unconstrained openness. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of great openness once the human realm has been emptied. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali C

C. JA (7) Ice rgyal bar ti



Transliteration

1. §// e ma ho g.yo med zhi ba'i
2. stobs kyis 'thab rtsod lha men 'dren /
3. Ice rgyal bar ti'i sku la gsol bas 'deb /
4. bcudng (bcud dang) ldan pa'i =/ snodng (snod dang) ldan pa'i
5. dbang bskur bas / 'thab rtsod lha men
6. stong nas / zhi ba cheno'i (chen po'i) stobs dang
7. ldan pa'i dbang thobr (thob par) gyur 1 //
8. a phad / ōṃ phad / hūṃ phad / // //

Translation

How wonderful! Homage to the body of Ice rgyal bar ti, who guides the quarrelsome demigods with the power of unwavering peace. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of the power of unwavering peace once the realm of the demigods has been emptied. *A phad / ōṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali D

D. TA (9) gSang pa ngang ring (gSang ba ngang ring)



Transliteration

1. S// e ma ho sgribs med yees (ye shes)
2. stob kyis klen lkugs byol song 'dren /
3. gsang ba ngang ring sku gsol =/ bcudng (bcud dang)
4. ldan pa'i =/ snodng (snod dang) ldan =/ lta ba
5. phyargya (phyag rgya) cheno'i (chen po'i) dbang =/ klen lkugs
6. byol song gtong zhing =/ yees (ye shes) cheno'i (chen po'i)
7. stobs dang ldan =/ a phad / ōṃ phad /
8. hūṃ phad / //

Translation

How wonderful! Homage to the body of gSang ban gang ring, who guides stupid dumb beasts with the power of immaculate wisdom. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of emptying the realm of stupid dumb beasts and of the power of great wisdom. *A phad / ōṃ phad / hūṃ phad /*

Paper

Laid paper with cloudy fibre distribution and some fibre bundles as well as outer bark particles

Colourants

Azurite, carbon, cinnabar, gold, indigo, kaolinite, orpiment

Tsakali E

E. THA (10) Mu cho ldem drugs (Mu cho ldem drug)



Transliteration

1. §// e ma ho dmigs med sbyin
2. pa'i stobs kyi yidg (yi dag) bkres skom̐s
3. skom̐s 'dren // mu cho ldem drug
4. sku la gsol bas 'deb / bcudng (bcud dang)
5. ldan pa'i slobd dpon kyi / snod dang
6. ldan pa'i slobd ma la / lta ba phyargya (phyag rgya)
7. cheno'i (chen po'i) dbang skur bas / bkres skom̐
8. yidg (yi dag) stong nas / sbyin pa cheno'i (chen po'i)
9. stobs dang ldan pa'i dbang thobr (thob par) gyur 1 /
10. a phad / òṃ phad / hūṃ phad / //

Translation

How wonderful! Homage to the body of Mu cho ldem drug, who guides hungry and thirsty tormented spirits with the power of impartial generosity. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of great generosity once the realm of the tormented spirits has been emptied. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with fibre bundles

Tsakali F

F. DA (12) Ti sang rang bzhin (Ti sang rang zhi)



Transliteration

1. S// e ma ho tshad med byams pa'i
2. stobs kyis tsha drang myal ba 'dren /
3. ti sangs rang zhi'i sku la gsol bas
4. 'deb / bcudng (bcud dang) ldang pa' =/ snodng (snod dang)
5. ldan pa'i slob =/ yid ches grubs =/
6. lta ba phyargya (phyag rgya) cheno'i (chen po'i) =/ tsha grang myal
7. ba stong nas =/ byams ba cheno'i (chen po'i) stob dang
8. ldan pa'i dbang thobr (thob par) gyur 1 / a phad /
9. òṃ phad / hūṃ phad / //

Translation

How wonderful! Homage to the body of Ti sang rang zhi, who guides those in the hot and cold hells with the power of limitless compassion. The master who has the elixir having bestowed on the disciple who is the vessel the empowerment of the great seal of the view that has been realised with great confidence, may you receive the empowerment of limitless compassion once the hot and cold hells have been emptied. *A phad / òṃ phad / hūṃ phad /*

Paper

Woven paper with cloudy fibre distribution and some fibre bundles as well as outer bark particles

Tsakali G

G. 'I Chag med ye shes g.yrung (g.yung drung)



verso blank

Paper

Woven paper with cloudy fibre distribution and some fibre bundles as well as outer bark particles

Tsakali H

H. {ZA} rKo 'o Yees (ye shes) rgyal mtshan



Transliteration

1. §// e ma ho / bdeen (bde chen) gling gis
2. gnas mchogs nas / ngoob (ngo bo) rangin (rang bzhin)
3. gdod nas rnam̐s par dag / ma sgrib
4. yees (ye shes) rigs pa rang la shar /
5. gnyis med mtha' bral yees (ye shes)
6. rgyal^n kyis / 'gyur med ngang
7. du dbang bskur byis kyis bu 'di
8. la / bka' rgyud mlas dbang
9. bskur bas / brgyud lung man
10. ngag rdzogs pa'i dbang thobr (thob par) shog /
11. 'ghu ru dz+nya na sha trang / a ðṃ ḥṃ //

Paper

Woven paper with fibre bundles

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