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Arts and Sciences. A Personal Perspective of Tibetan Painting

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Abstract: The relationship between the arts and the sciences is discussed from the standpoint of a scientist and passionate art lover. The two playgrounds of human creativity have much in common and have cross-fertilized each other over centuries. An active involvement in an artistic discipline can stimulate scientific creativity by direct analogy and by emotional and intellectual experience. The excitement of a scientist for the arts is exemplified by the author's adventures in Tibetan painting. The scientific study of Tibetan thangka is discussed by examples from the author's collection. The analysis of pigments and the dating of the paintings are covered. In addition, some background information on the historical and iconographic context is given.

Keywords: Arts and sciences · Dating of paintings · Pigment analysis · Tibetan Buddhism · Tibetan thangka

Arts and Sciences

Much has already been written about the hidden link between the arts and the sciences. The two highly creative fields are evidence of the ingenious human mind. Human culture could hardly be conceived without the arts or without the sciences. They belong inseparably to us and form essential parts of our identity.

At first sight, the two domains of creativity have developed appearances as disparate as possible. Especially the contemporary arts have liberated themselves from all conceivable constraints. For example in painting, the abstract styles introduced during the first half of the 20th century by visionary painters, such as Wasily Kandinsky and Jackson Pollock, abandoned all preestablished 'natural' patterns in order to create a novel universe reflecting exclusively the painter's intent. Similar trends characterize the developments in 20th century music. The atonal musical inventions by composers like Anton Webern and Arnold Schönberg are based on their own set of rules

which have no equivalence in former periods or in nature. And with the aid of the computer-based synthesis of music and of graphical creations, the very last limitations, imposed by the difficult musical instruments and the painter's self-willed brush, are overcome, leading to a complete liberation of the creative artist's mind. Breaking as many barriers of convention as possible seems to have become the trademark of a respected artist. The great works of modern art still express eternal truths, but through the individualized perception of an artist who values his own emotions and imaginations infinitely more than the conventions of society.

The fundamental task of the sciences, on the other hand, is understood to be the objective search for the laws of nature, which are believed to have absolute validity and should in no way reflect the momentary emotions of the scientist who has discovered them. Restraining the researcher's emotionally driven personality, while performing reproducible experiments, collecting objective and truthful data, conceiving explanations, and writing papers in a style as impersonal as possible, seem to be very basic prescripts of the scientific profession. The researcher, so-to-say, establishes merely an intellectual link within the machinery of information acquisition. To some extent, his

function may equally well be performed by an intelligently programmed and powerful computer which has the advantage of not being distracted by emotional desires.

How boring must it be to meet one of these 'perfectly objective scientists'! Persons without personality! True functionaries and operators! – But how different are in fact some of our greatest and most respected scientists! Men and women with deeply humanistic and emphatic personalities, individuals with a broad horizon and often with more cultural knowledge than those who professionally deal with culture. Often scientists possess highly developed artistic skills, some are excellent graphical artists, others write handsome novels, and, perhaps most frequently, one encounters devoted and superbly performing musicians among our top scientists.

One may conclude that even 'real scientists' have a hidden humane side. Their minds are not entirely satiated by objective research activities, and they are in need of a complementary humanistic or artistic 'hobby'. To some extent, the complementarity of the arts for supplementing what a scientist misses during his specialized daily occupation might indeed provide some explanation for the extra-scientific activities of scientists. But it does not convey the full truth.

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In fact, there is at least as much commonness as there is disparity between the 'exact' sciences and the 'liberal' arts. First, the sciences are not at all as objective and 'exact' as stated above and often maintained by the proponents of absolute scientific truth. A great deal of human intuition and imaginativeness is necessary for the rationalization of scientific measurements. Although the discovered 'laws of nature' may explain perfectly all known experimental facts, they are merely humane model perceptions, but cannot be claimed to be 'absolute' in the true sense of the word, and they involve often as much 'invention' as they are 'discoveries'. According to the principles of cognition, we are never capable of achieving more than the construction of models that match nature. 'True' nature can only be guessed but never proven. In many ways, the design of such theoretical or heuristic models requires as much creativity and intuition as is needed in the arts. It is well-known that also in the sciences beauty, simplicity, and symmetry often distinguish the superior theories from the less successful ones. We must 'love' a theory before we are ready to accept it. Aesthetics clearly has great importance in the sciences. It seems, for example, not too far reached to compare in terms of creativity the conception of relativity theory with the invention of the *Odyssey* by Homer or the *b-minor mass* by J.S. Bach.

On the other hand, the stringent scaffold or corset imposed upon the freedom of the researcher by the experimental data, which are not allowed to be manipulated under any circumstances, is not unique to the sciences alone. Also the arts know a multitude of scaffolds or corsets which the artists are not permitted to violate without forfeit. First of all, in the traditional, classical arts, the obedience of strict rules was a prerequisite for receiving a quality label. A skilful painting must fulfill general rules of composition for easing the eye's journey through its contents. Also in traditional musical composition, a very extensive system of rules in terms of classical harmonics and counterpoint governs the interplay of the voices. And even the most radical composers of the 20th century have postulated rules which they themselves deliberately obeyed. Paul Hindemith has developed his own strict and logical system of composition in '*Unterweisung im Tonsatz*', and Arnold Schönberg created his famous 'twelve-tone system' which forms an exceedingly stringent scaffold that drastically limits the freedom of serial

compositions. Another example of self-imposed restriction in the arts are the mystics of numbers in J.S. Bach's compositions and those of many others. It seems that also artists need hurdles, barriers, or fringe conditions against which they can fight in order to stimulate or channel their creativity, in a similar manner that scientists have to pay unrestricted obedience to experimental data. – And above all, the artist is compelled to express the message he has in mind or that is on his task sheet. Especially in commissioned art, the restrictions imposed upon the artist might be extremely severe. In medieval times, the majority of the art production was connected to its religious function, and religious dogma had to be followed very strictly. In fact, painters and musicians in the middle ages were considered as craftsmen, rather than liberated artists.

In summary, there are indeed intimate relations between the arts and the sciences. Both fields require intuition and creativity, and in both fields greatness is measured by the mastery of inherent difficulties and nevertheless expressing eternal truths or achieving eternal beauty. It is sometimes said that a sculptor liberates a sculpture which is already invisibly contained in the raw block of hard rock, in the same way that a scientist reveals the laws of nature hidden in the raw experimental data. Or it is claimed that those human beings who are capable of preserving during their entire lifetime their youthful curiosity and spontaneity may become scientists or, in the best case, artists.

It is only natural that revolutionary scientists are attracted by the revolutionary arts. They intuitively feel the relatedness and they often find open-minded interlocutors in the arts, revealing congeniality and leading to friendship. Frequently, they are stimulated in their professional endeavors by great works of art. Patterns of reasoning and perception have often been transferred directly from one discipline to the other. There are also numerous artists who are fascinated by the sciences and are stimulated by scientific discoveries and reasoning. If nothing else, science provides novel means which artists might exploit to express better their artistic intentions.

My Personal Attraction to the Arts

The arts intrigued me already during my adolescence, before I attempted to become a halfway respectable scientist.

At that time, I devoted most of my leisure time to musical performance and composition, besides experimenting with fascinating chemicals in the basement of our home.

Music opened, so-to-say, a door to higher spheres of perception which went way beyond the daily sensations in school and family. Still today, I cannot live for long without musical stimulation, although I have little occasion for active performance. Experiencing classical music of all shades is nearly as important to me as is breathing air.

Later I discovered the fascination of European literature and European painting. As much as in music, I tried to avoid the commonly traveled paths. I became interested in early Romanesque and Gothic painting, on the one hand, and in 20th century painting on the other. Medieval religious art provided me, being myself at most an agnostic, a fascinating access to nonverbal spirituality and to religious symbolism, complementing my musical experiences which had a similar vital function.

Only much later, in 1968 during a journey to Asia, a first unexpected contact with Asian arts and in particular with Buddhist art revealed a fascinating new world of cultural and philosophical experiences. This lucky event initiated my insatiable interest and excitement for Tibetan art. It shall serve as a personal example for illustrating the fascination of a scientist by the arts.

Tibetan Art, an Example

What makes Tibetan art [1–10] so attractive to a western physical chemist? What is it about the art of one of the poorest countries with a tiny population of perhaps two to four million, remote from all the great, highly populated cultural centers of the world that causes so much fascination? – In spite of its geographic inaccessibility, important cross roads for trade and also for cultural exchanges passed through there. The famous silk road was not too far away to the north and the Himalayan passes provided frequently utilized, although arduous passages from Nepal and India to the northern plains, to the sacred Kailash mountain, and to the salt lakes of the Chang Tang.

The great Asian cultures not only cut through Tibet, but these rugged highlands had a surprising retaining power for cultural inspirations and treasures. Many ancient cultural documents and religious

traditions remained in the remote mountain region, while in the open lowlands of South and East Asia, they were extinguished and replaced by cultures of more aggressive proponents. In particular, Buddhism [11–15], perhaps the most peaceful and least aggressive philosophical system of mankind, persisted there and even survived (so far) the incredibly brutal, thoughtless, materialistic, and hegemonic attempts of the Chinese governments towards its extinction.

Tibetan Buddhism (often inaccurately called 'Lamaism') developed into an all encompassing State religion which penetrated and determined all conceivable aspects of life [16–19]. This gave it an absolute dominance, but also led to isolation and made it, after all, vulnerable to external aggressors. Exuberant cultural and artistic production resulted, completely incommensurate to the limited resources and to the hardships of life in these extreme altitudes. Despite the highly deplorable extent of destruction by the Chinese barbarians during the 1955 invasion and during the Cultural Revolution, a surprising wealth of religious artifacts of highest quality remained. Much of it was produced for vocational donations to monasteries and has respectfully been stored away for up to twelve centuries. For this reason, even very early treasures from the 11th and 12th century remain, sometimes, in an almost perfect state of preservation.

In spite of the philosophical nature of the Buddhist eternal wisdom and the rather atheistic concepts of Buddha Sakyamuni's teaching, Tibetan Buddhism, and in general northern or Mahayana Buddhism, developed a surprisingly rich pantheon of deities, of protectors (dharma-palas), of saints (arhats), of yogis (mahasiddhas), and of deified historical personalities [20–22]. Several hundred deities, many with numerous local and circumstantial variants, are known and are represented in encyclopedic collections [23][24]. All of them are iconographically well characterized by the number of their heads, arms, and legs, by their posture (asana and sthana), by the positions of their hands (mudras), by their color, and by the attributes they are carrying [20–22]. It is not surprising that this animated fantastic universe offered fertile grounds for imaginative painters and sculptors. Verbal descriptions of the deities alone remain largely inadequate.

It should be remembered that the immense pantheon has, for a knowledgeable Buddhist, no objective reality in the sense of fundamentalist Christian super-

stition. Basically, Buddhism remains in fact atheistic [14]. The various deities are symbolic representations of abstract spiritual concepts which are essential for mastering our life and for human interrelations. It has often been pointed out that the faithful Buddhist, meditating in front of a thangka painting or a sculpture, meditatively invokes and inspires the painted deity. Evident examples in this respect are the offering paintings (*rgyan-tshogs*, host of ornaments) [25] where the deity to be represented is not shown at all but only indicated by his attributes and his ornaments, and the meditator has to 'project' the deity mentally into the (purposely incomplete) painting.

Tibetan Thangka Painting

We concentrate here exclusively on the art of thangka painting and do not mention the equally important Tibetan metal sculptures which are often of stupendous quality [26]. A thangka is a scroll painting, normally on cotton cloth and often framed in Chinese silk brocade [27–29]. On rare occasions, silk or other fibers, such as hemp or flax, are used as the painting support. The cloth on which the painting is to be done is fixed and stretched on a wooden frame, and covered with a gesso consisting of chalk, gypsum, or kaolin mixed with an aqueous hide glue solution. Hide glue is prepared from the skin of yaks or other animals and consists mainly of gelatin. Hide glue is the binder medium for virtually all applications in Tibetan art. Especially, it is used for applying the pigments during painting. It complicates the process of painting by having to handle hide glue at a slightly elevated temperature (30–40 °C) in order to avoid gel formation.

On the dry gesso, an outline is sketched with charcoal or black ink, often using a sophisticated grid construction to arrive at the proper proportions of the figures [27]. Then, the painting process starts by applying one pigment after the other. To finish, some shading may be added to the larger pigment-covered areas and, finally, contours and important details are highlighted by black ink and by gold paint.

Most of the pigments used in Tibetan thangka painting are of natural mineral origin [27]. Many are found in Tibet, others had to be imported. Pigments were, from very early times, valuable trade items which may have traveled quite far by caravans. Frequently encountered traditional mineral pigments are: red: cinnabar (HgS) [30]; orange: realgar (As₂S₂) [31]; yellow: orpiment (As₂S₃) [31] and yellow ochre (Fe₂O₃·nH₂O) [32]; green: malachite (CuCO₃·Cu(OH)₂) [33] and verdigris (mCu(CH₃COO)₂·nCu(OH)₂·pH₂O) [34]; blue: azurite (2CuCO₃·Cu(OH)₂) [35]; black: carbon black; white: chalk (CaCO₃), gypsum (CaSO₄·2H₂O), and kaolin (Al₂(Si₂O₅)(OH)₄). Some inorganic pigments were produced synthetically, for example orange red lead (Pb₃O₄) [36], yellow massicot (PbO) [37], smalt [38], a blue cobalt glass, and also cinnabar. Lapis lazuli and artificial ultramarine were rarely used. The most important traditional pigments of organic origin are indigo (C₁₆H₁₀O₂N₂) [39], which was imported from India and was very frequently used in Nepalese paubha painting but occasionally also in Tibet, and lac lake [40], which was produced locally. During the past two centuries, some western synthetic pigments also found their way into Tibet, for example Prussian blue (Fe₄[Fe(CN)₆]₃) [41].

For the final shading of larger areas, either very thin preparations of the above pigments were applied, or the painters used dyes of organic origin, including indigo, red lac dye, red sandalwood dye, yellow saffron, and a yellow dye prepared from the petals of a wild rose [27]. The outlining of larger areas was done with dark preparations of the corresponding pigment, indigo or with carbon black ink.

Especially tricky is the preparation of the sometimes extensively used gold paint [42]. The major problem is the grinding of the ductile gold into a sufficiently fine powder with a particle size in the order of a few microns. Sometimes secret recipes were developed which are still commercially used today by Newars in Katmandu. Some manufacturers employ a carbohydrate medium, for example honey, during the grinding process, others start with gold amalgam.

Thangkas have often been produced by professional lay painters in larger workshops, not necessarily associated to a particular monastery or to a particular congregation. Frequently, several painters worked on a single thangka. For example, it was usually a master painter who inserted at the very end the eyes of the displayed figures. But there were also painting workshops with monk painters within monasteries.

A very rare insight into such a monastery painting workshop is given on a thangka in the author's collection, published in [8][10], and [43]. As indicated by its front-side inscriptions, the detail

Fig. 1. Detail (27 x 35 cm), showing the thangka painters' workshop of Zhu-chen Tshul-khrims-rin-chen, from a thangka with episodes from the life of the Ngor abbot Rin-chen-mi'gyur-rgyal-mtshan. Painted between 1751 and 1774 in Derge, Khams, eastern Tibet. Entire painting 79 x 58.5 cm.



shown in Fig. 1 displays the atelier of the famous lama painter Zhu-chen Tshul-khrims-rin-chen (1697–1774) who was active in the east Tibetan monastery of Derge in the Khams province [8]. The master, seen on the right, prepares the design of a painting, and on the left his disciples are coloring thangkas (and in front, a good-for-nothing enjoys the ongoing outside activities). The detail shown is from a painting displaying episodes from the life of Rin-chen-mi-'gyur-rgyal-mtshan (1717–?), the former 37th abbot (1746–1751) [44] of the important Ngor monastery in central Tibet who visited later Derge [8]. Both monasteries, Derge and Ngor, are associated with the art-loving Sakya tradition. The exceptionally informative thangka must have been painted in this very same workshop between 1751 and 1774.

Scientific Questions and Approaches in the Context of Thangkas

Thangkas are normally stored in rolled form. Cracks and paint loss are quite frequent due to rough mechanical handling. In addition, the water-based paintings are very sensitive to humidity,

and although Tibet has a relatively dry climate, occasional rain may have penetrated through leaky roofs and damaged the precious thangkas stored away for centuries. Thangkas displayed for an extensive time suffered from the smoke of the all abundant butter lamps. Frequently, spills of butter have additionally damaged the surfaces. In other words, cleaning, restoration, and conservation of thangkas are often indispensable and highly demanding tasks [45–49]. The more scientific knowledge that is available, the better the thangkas can be handled by the conservators.

The following questions may arise in the study and conservation of thangka paintings:

- (i) Date of the painting
- (ii) Geographical origin of the painting
- (iii) Material of the supporting textile
- (iv) Type of gesso applied
- (v) Chemical composition of the pigments used
- (vi) Origin of the binder used for preparing the paints and the gesso.

The analysis of pigments can be done by chemical microscopy, by microanalyses under the microscope [32], by Fourier-transform infrared spectroscopy (FTIR)

[50], by element-specific spectroscopic techniques [51][52], and others.

Besides the benefits of answering questions in view of conservation and restoration, knowledge of the painting techniques is of historical interest. It allows a more accurate perception of the circumstances under which the art works have been produced. Issues of research on thangka paintings will be discussed for some examples of thangkas from the private collection of the author.

1. Four Kagyupa Monks

The thangka of Fig. 2, published in [10], is a historical painting, showing four historical personalities as the main figures. However, the absence of any inscriptions does not straightforwardly allow their identification. On the other hand, the smaller figures are more easily identified. They represent the main lineage of descendants of the Kagyu tradition [53] from the Adibuddha (primordial Buddha) Vajrasattva, shown at the top center in his characteristic position (asana) and carrying vajra (male symbol) in his right and ghanta (female symbol) in his left hand flanked by the two main Indian Mahasiddhas (yogis) of this tradi-



Fig. 2. Central Tibetan thangka showing two pairs of meditating lamas surrounded by their lineage which relates them to the Adibuddha Vajrasattva in the upper center. 12th to 13th century. 80 x 55 cm.

tion: Tilopa (928–1009) on the left and his disciple Naropa (956–1040) on the right. The lineage of teaching is continued with the Tibetan translator Marpa (1012–1097) at the lower left and his disciple Milarepa (1040–1123), perhaps the greatest Tibetan poet, at the lower right. Finally, the most influential disciple Gampopa (1079–1153) [54] of Milarepa is shown in the center of the painting. But who are the four major Lamas? Because the lineage of teaching is so important on thangka,

it is tempting to assume them to be four disciples of Gampopa [53]. Indeed, Gampopa had four disciples, each of whom founded a branch of the Kagyu tradition: Dusum Khyenpa (1110–1193) the first Karmapa, Phagmo Grupa (1110–1170) the founder of the Densatil monastery, Dakpo Gomtsul (1116–1169) the originator of the Tsalpa branch, and Barom Dharma Wangchuk (?–?) the founder of the Barompa branch of the Kagyu tradition.

The faces of the four lamas are in a very subtle way personified. Minute differences are used to characterize their physiognomy. The big open eyes and the round faces radiate open-mindedness and peacefulness. Despite this subtlety, Christian Luczantis [55] claimed to recognize the upper left figure as Phagmo Grupa. It is apparent that the two grey-haired lamas on the left are of advanced age, while the two on the right seem to be a generation younger. This purposeful representation does not match the historical ages of the four disciples of Gampopa. It seems more likely that each of the two pairs represents a teacher and his disciple. The two by far most important students of Gampopa were Dusum Khyenpa and Phagmo Grupa. Thus, one may identify the lower left teacher with the first Karmapa, Dusum Khyenpa. He also rather closely matches the physiognomy of a famous contemporary statue of him [53]. The two figures on the right might be influential students of them, perhaps Tangpa Chenpo (1142–1210), the founder of the important Taglung monastery in the upper row, and Jigten Gampo (1143–1212), the founder of the Drigung monastery in the lower row. The documented physiognomy of Tangpa Chenpo [56] somewhat matches the upper right figure. Obviously, this identification is at best preliminary, having no reliable identifiers at hand.

Portrait thangka painting is often done in honor of a great teacher after his death. Frequently, the donor of the painting is also integrated into it, often in one of the lower corners. But paintings of great masters done during their lifetime are also known. It is thus likely that the thangka was painted between about 1160 and 1220.

On overall stylistic grounds, one is tempted to date the painting between 1100 and 1300. There are ancient elements in the painting which rather suggest the first half of this period. For example, the very characteristic thrones of Tilopa, Naropa, Marpa, and Milarepa, each with two side towers, topped by tiny stupas, rarely appear in thangkas after about 1250. These are remainders of the early influence by the north Indian Pala art. Also the golden and decorated triangles to the left and right of each main figure on the head level are remainders of early thrones. They became by then a purely decorative element without a clear function. It survived well into the 15th century, but is rarely found later. The lotus pedestals of the main figures each contain two blue lion heads and two red-

nosed green elephant heads. These symbolic decorations seldom occur in paintings after about 1300. These considerations allow one to suggest, on stylistic grounds, a date between 1100 and 1250, in agreement with the historical reasoning.

^{14}C dating of the cotton on which the thangka is painted has been done [57]. The calibrated and corrected ^{14}C date is 1169–1290 with a mean of 1229. This result favorably matches with the above suggestions.

Microscopy shows that this thangka has been painted on a heavy piece of cotton covered with a very thin gesso of greyish chalk. The threads are still visible in the structure of the painting surface. Chemical microscopy reveals the usage of the following pigments: The dark blue paint of the sky consists of azurite, and the faint bluish shades are prepared with indigo. The two blues can easily be distinguished under infrared light where azurite appears dark and indigo bright (verified chemically). The red is, as usual, cinnabar. The yellow consists of orpiment on a chalk support, and the green is produced by mixing indigo with orpiment. The extraordinarily bright white consists of gypsum and chalk.

Dating of Thangkas

In fact, the three procedures applied above are the major tools available for estimating the age of thangkas: Lineage, ^{14}C analysis, and style of painting. In the case of Nepalese Buddhist and Hindu paintings (paubhas) [58–60], an accurate date is usually included in the inscription. Unfortunately, Tibetan paintings almost never contain a date.

Dating Based on the Lineage

Following the lineage is relatively safe, provided the names of the teachers are indicated or they can be identified based on their physiognomy [8][61][62]. Usually, a lineage stops with the donor of the painting and fixes a production date within his active life time. Later reproductions of earlier paintings of this kind are so far unknown (except for recent fakes) and contradict the purpose of establishing an unbroken link to the donor.

Dating by ^{14}C Analysis [63–65]

^{14}C analysis is the only truly quantitative method available for paintings. But it has numerous inherent limitations: (i) The dating refers to the support material which could be older than the painting itself. This is of particular relevance for wooden objects where the ^{14}C date re-

flects the date of growth of the part of the tree stem that has been used. (ii) The precision of the ^{14}C content measured by accelerator mass spectroscopy limits the accuracy of the dating usually to ± 50 years, depending on the period to be dated. (iii) Contamination by more recent, insoluble material, for example deposits from the smoke of butter lamps, dust or material from recent attempts of conservation, may lead to too recent dating. (iv) An inherent source of uncertainty is the irregular production rate of ^{14}C in nature. It can cause grave ambiguities in the dating. This unfortunate fact of nature may be appreciated by the calibration curve in Fig. 3. The dating is hampered particularly in the ranges 1000–1150, 1260–1420, and 1460–1620. In these periods, the dating uncertainty is grave. For paintings after about 1660, dating by ^{14}C analysis is virtually impossible. Often, it is merely possible to distinguish material produced before or after the nuclear bomb testing of the 1950s. The examples presented in the following demonstrate the limits of ^{14}C dating in the time range relevant for thangkas.

Dating by Stylistic Analysis

Stylistic analysis is in practice often the only method used by 'Tibet experts', who have seen plenty of previously (often incorrectly) dated thangkas. Applying the acquired stylistic instinct permits an effortless on-the-spot dating to perhaps ± 50 to ± 100 years. But the result can be completely off under special circumstances, as demonstrated by the following example.

2. Portrait Thangka of Jigten Wangchuk

The thangka shown in Fig. 4 belongs to an extensive series of paintings, each displaying a hierarchy of the Kagyu tradition, related to the monastery of Taglung. Two thangkas of this series are in the author's collection, published in [10]. Others are not (yet) known. Series of related thangkas, usually with inscriptions on the backside indicating their order of hanging, have a long tradition in Tibet. They are often symmetrically grouped to the left and right of a central image display-

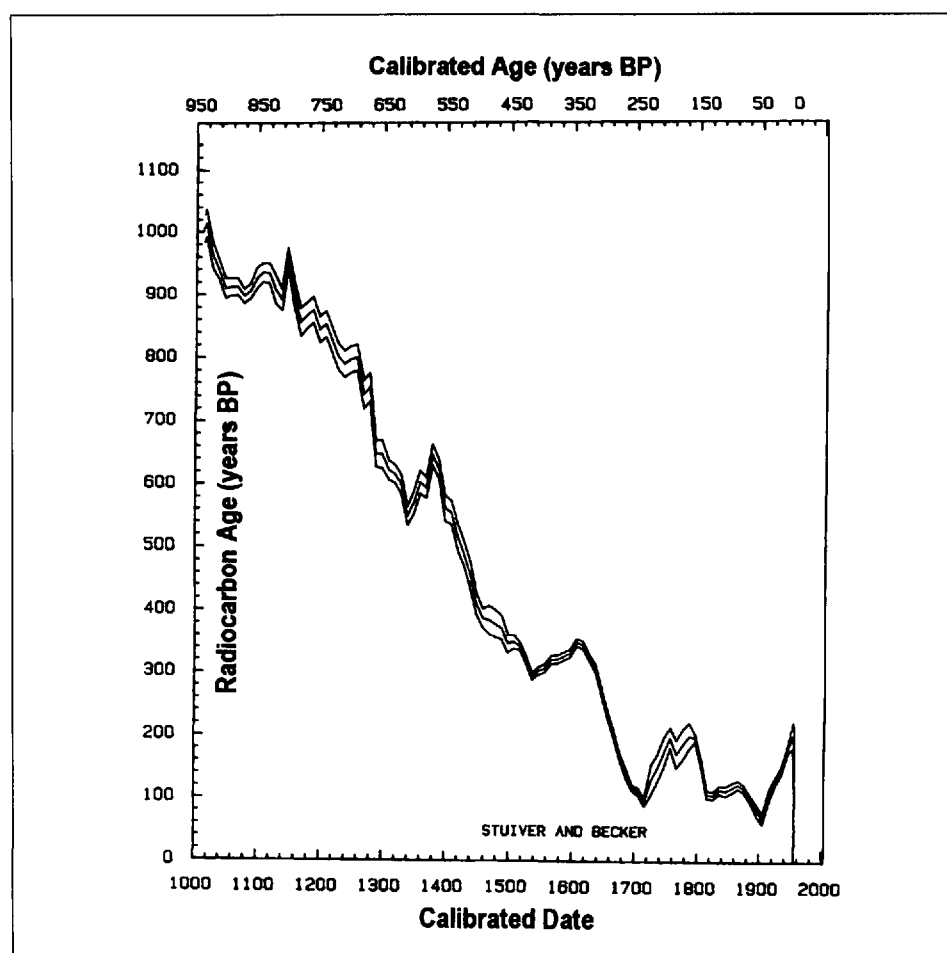


Fig. 3. Relationship between the radiocarbon age (years before 1950), determined by ^{14}C analysis, and the calibrated date (together with the calibrated age in years before 1950), determined by dendrochronology (adapted from [64]). The curve, accompanied by the 1σ error limits, demonstrates the uncertainties in ^{14}C dating.



Fig. 4. Portrait thangka of the Kagyupa hierarch Jigten Wangchug (1454–1532) together with the lineage connection from the Adibuddha Vajradhara. Probably painted between 1540 and 1560. 37 x 31 cm.

ing a specially venerated deity which, in this case, is unknown.

Stylistically, the two thangkās can easily be dated to the 13th or early 14th century. The most characteristic item is the stylized mountains behind the throne of the main figure with their alternation of reddish and greenish stripes. They seem remotely related to the mountains seen in some of the earlier Russian icons. Such mountain shapes were soon abandoned and rarely appear in thangkās after about 1350. Later, they are frequently replaced by typical Chinese mountain representations. Also the kind of structuring of the bluish area of the throne belongs typically to the same period. The general appearance of the two thangkās clearly reflects a 13th or early 14th century date.

The art historian is put into a rather comfortable situation when the names of the displayed historical personalities are inscribed (usually in golden letters), which is, in an international perspective, a rather uncommon, but in Tibet rather frequently used, procedure. It is evidence of the extent to which historical information was valued in Tibet. Indeed, thangkās combine a religious meditative purpose with the recording and transmission of documentary information.

The interpretation of this painting took a surprising turn when the beautifully written text on the reverse side and inscriptions on the front were read by Dr. Amy Heller [10]. Without doubt, the displayed hierarch represents Jigten Wangchuk who lived from 1454 to 1532.

He functioned as an abbot of the famous Kagyu monastery of Taglung and he transmitted the Kalachakra teachings to the Eighth Karmapa, Mikyo Dorje (1507–1554). It seems that the painting had been commissioned by his follower Rje mTsho skyes rdo rje (1530–1590) who is shown as the second from right in the lowest row. The remainder of the lineage can only partly be identified. But it is clear that it starts with the Adibuddha Vajradhara (third in top row), followed by Tilopa (second in top row), Naropa (fifth in top row), Marpa (first in top row), Milarepa (sixth in top row), and Gampopa (last in top row). It is likely that the thangka was painted between 1540 and 1590.

Thus the stylistic dating precedes the dating by lineage by more than 200 to 300 years. How can this be reconciled? Perhaps the two thangkās served to update an ancient series of thangkās, relating to the Taglung tradition, which was still on display at that time. The older members of the series might have been destroyed during the Chinese interventions, or only the better preserved, more recent members of the series have found their way onto the art market.

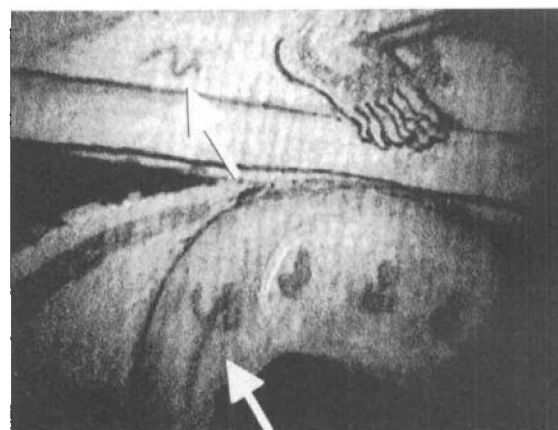
A recent ^{14}C analysis [66] gave, as a result of the problems mentioned above, the following possible ranges: 1527–1553, or 1633–1698, or 1722–1817, or 1920–1955. The earliest ^{14}C dating period would fit the other arguments nicely. The later periods, compatible with the ^{14}C data, appear less reasonable.

In the larger thangka painters' ateliers, where several painters were active, it became customary to indicate on the preparatory outlining of the painting the colors to be applied by a code so that another painter could complete the coloring [27][67]. But even for a single painter, these marks may have been handy. The marks were covered by paint and remain normally invisible. However by infrared photography or by viewing through an infrared viewer, they become apparent, except for dark blue, green, and black pigments which cannot easily be penetrated by optical means. In the two thangkās of the series, a mixed code of Tibetan digits and letters was used. Clearly visible are k = white, 2 = pink, 4 = green, 5 = blue, 7 (or l ?) = orange. The letter k stands in Tibet often for the number 1. The painter used two different blue pigments: azurite, which is dark in IR light (with invisible lettering), and indigo, which is bright in IR and is indicated by the digit 5. Also two green colors are applied: malachite (dark in IR with

invisible lettering) and indigo and orpiment (bright in IR, and indicated by the digit 4). Only, seemingly irrelevant, details (*e.g.* nimbuses and mountains) are color-coded. The colors of the essential figures must have been obvious to the painter.

For observation under IR light, a Find-R-Scope of FJW Industries was used, equipped with a near-range lens and an IR filter. It was adapted to a Zeiss Stemi SV11 microscope (using a 1.6x lens) equipped with a Polaroid DMC digital microscope camera for recording. An IR display of a detail from the other painting of the series (showing Palden Rinchen, and displayed in [10], plate 103) is given in Fig. 5. It shows the orange area (red lead = 7) behind a foot of the Yidam Mahamaya and the blue nimbus (indigo = 5) of the deity Vajravardana at the lower right of the painting.

Fig. 5. Infrared photo of a detail in the companion thangka to Fig. 4 mentioned in the text, showing the digit '7' for red lead in the upper left and the digit '5' for indigo in the lower center (marked by arrows). There is some overlap of the '5' by a gold mark on its right.



3. Bonpo Thangka of Takla Mebar

Let us make a brief excursion into another fascinating area of Tibetan art. Besides the Buddhist tradition, introduced during the reign of the famous and powerful King Songtsen Gampo (~617–649) and by the Indian magician Padmasambhava (~730–800) during the reign of King Thrisong Detsen (742–798), there exists a primordial Tibetan religion, called 'Bon' [68–72]. The adherents of Bon, the Bonpos, also produced thangkas and bronze sculptures which are surprisingly similar to the Buddhist ones [71]. Also the Bonpo thangka of Fig. 6, published in [10] and [73], is similar to a Buddhist representation of a protection deity.

From 640 to 840, Buddhism became the Tibetan state religion and Bon was expelled into rural hide-outs. Tibet covered, at that time, an astonishingly large area from the Oxus River (Amu Darya), eastern Afghanistan, and Turkestan in the west to Xian in the east, and from Bengal in the south (the 'Bay of Bengal' was once called 'Tibetan Sea') to Dunhuang and southern Mongolia in the north [74][75]. But in 841, the Tibetan King Langdarma was murdered by a Bonpo monk who was supported by unhappy feudal rulers. And it took 200 years before Buddhism could recover, by a second spiritual influx from India, particularly by the teachings of the famous scholar Atisha (982–1054) who arrived in Tibet in 1042. Later, a peaceful co-existence of Bon and Buddhism developed.

Two explanations exist in art science circles for the surprising similarity of Bon and Buddhist rituals [76]. The first



Fig. 6. Bonpo thangka of the yidam Takla Mebar surrounded by numerous Bon deities and Bon priests. Late 18th to 19th century. 118 x 82 cm.

one maintains that Tibetan Buddhism has integrated earlier Bon traditions and the Bon pantheon into Buddhist practice. It is known that Buddhism has indeed a great assimilating power and easily allows for the simultaneous practicing of other traditions as well. On the other hand, in order to survive, Bon also had to adapt, and it enriched its dogma by Buddhist concepts.

A second explanation was suggested by B. Laufer [77] and D.L. Snellgrove [78]. They suggest that the pre-Buddhist Bon reflects an earlier wave of Buddhism that reached Tibet. Perhaps already during the first century AD, Buddhism might have spread *via* the Kushana empire in northern Pakistan and Kashmir into western Tibet and into a legendary area called Zhangzhung, which is believed to be the area of origin of Bon. Because of the lack of written tradition, a distorted form of Buddhism could have resulted, incorporating also earlier local animistic beliefs. Still today, a lot of mystery accompanies the origin of the Bon teachings.

The principle figure on the thangka of Fig. 6 represents Takla Mebar who is considered at the same time as a 'siddha', a (often historical) master of meditational and ritual practices, and as a 'yidam', a focus of a meditational practice, called tantra. Takla Mebar or the 'Tiger-god, flaming fire', is sometimes also claimed to be a protector against the Buddhists. Indeed, he is a deity without direct correspondence in the Buddhist pantheon. He carries in his right hand the wheel of the dharma and in his left hand the nine crossed swords giving him power over all 'nine ways of Bon' which represent the major Bon tantric practices documented in the Bonpo script *gZi-brjid* [78]. He has a third (tantric) eye, flaming hair, and is surrounded by a circle of flames, like most protector deities. He is accompanied by numerous minor deities, most of them identified by their names.

Unlike the frequent difficulties of the iconographic identification of Bonpo paintings, this one does not pose many problems. However questions remain about the date of production and about its geographical origin. The quality of painting is unusually high for a Bonpo painting and might have been executed in a workshop producing Bon and Buddhist thangkas side by side. Three details might provide further clues. First, the encircled figure at the lower right is Machen Pomra [71][79], a local protector residing on the Amye Machen mountain massive in Amdo which is spiritually part of 'greater' Tibet. Indeed, there are still today numerous Bonpo monasteries in

Amdo, and it is not likely that the painting is of eastern Tibetan origin. Second, the Tibetan inscriptions of names are connected by very thin pointed gold lines with the respective figure. This is a highly unusual procedure to enhance clarity (even where it is absolutely unnecessary). No further thangkas (except for a second member from the same series, showing Nampar Gyalwa, also in the collection of the author) are known in collections outside of Tibet displaying the same feature. However, Per Kvaerne has photographed on a field trip to the Ngawa area of eastern Tibet, presently part of Sichuan, a thangka, displaying Shenla Wökar, which shows the same curious feature [71][80]. It is likely that the thangka shown here originates from the Ngawa area or possibly from nearby Gyarong. In both areas, the Bonpos had traditionally a rather strong hold.

An indication of its date of creation is provided by an analysis of the pigments. While most of the pigments used in this painting are traditional, such as cinnabar and red lead, a chemical analysis of a small particle of blue pigment under the microscope (Zeiss Axiolab with polarizing accessory and 100x magnification, equipped with an ISIS vision enhancing system by Vision Engineering Ltd.) produced a positive test for iron with potassium thiocyanate in HCl solution [32]. Among the feasible blue pigments, only Prussian blue ($\text{Fe}_4[\text{Fe}(\text{CN})_6]_3$) is compatible with the analysis. An FTIR spec-

trum, shown in Fig. 7 [81], clearly confirms the finding. It is known that Prussian blue was synthesized for the first time in 1704 or shortly thereafter [41]. It has been frequently used in European paintings in the second half of the 18th century. It was also produced in Goro-dets, Siberia, before 1778. It is quite possible that by the end of the 18th century, Prussian blue found its way into China and in the Ngawa or Gyaong area through merchants *via* Chengdu. Prussian blue achieved immediate popularity, being much easier to handle and less expensive than azurite. Also rather unusual for a Tibetan thangka, the FTIR spectrum reveals that the support for the Prussian blue is lead white, $2\text{PbCO}_3 \cdot \text{Pb}(\text{OH})_2$. Normally, Tibetan painters refrain from using lead white which is known to be incompatible with cinnabar and orpiment. Taking into account the highly sophisticated and nevertheless enlivened style and the aged condition of the silk frame of a second painting of the same series in the author's collection, it is suggested that the series of thangkas were painted between 1780 and 1840.

Another Bonpo painting, also in the author's collection, showing the powerful ten-armed deity Kun bzang rgyal ba 'dus pa [82], employs a further unusual blue pigment. Chemical analysis and a spectroscopic investigation [81] confirm the usage of smalt, which is a finely ground potassium glass of blue color [38]. The blue originates from cobalt

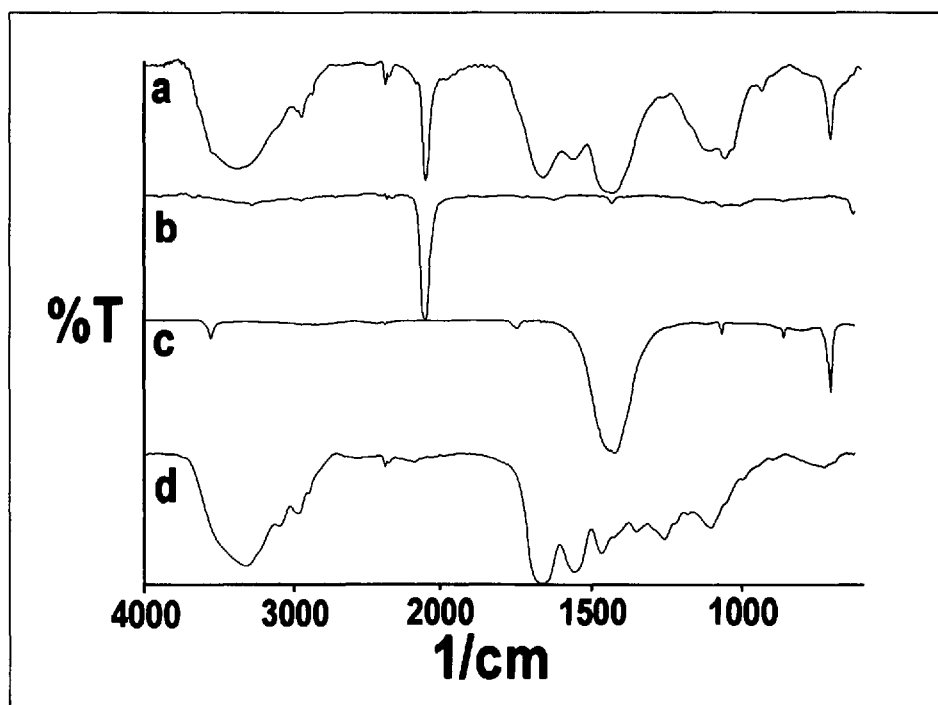


Fig. 7. (a) FTIR spectrum of blue pigment of the sky in the thangka of Fig. 6, (b) Reference spectrum of Prussian blue. (c) Reference spectrum of lead white. (d) Reference spectrum of gelatin. Recorded with Perkin-Elmer System 2000 [81].

added during its manufacture. It is chemically extremely inert and its grains are of irregular shape. This allows an easy distinction from other blue pigments by chemical microscopy. It is known that smalt was prepared and used in central Asia already during the 11th century. It has been found in remainders of wall paintings in the ruins of the Tangut city Khara Khoto [38][83], occupying an oasis in the Gobi desert. Smalt is not known to have been used in central Tibet, and its occurrence could be an indication of a northern origin of the thangka. Bonpo activities are well documented in north-eastern Tibet.

4. Yamantaka, the Conqueror of Death

The remarkable painting of Fig. 8, published in [10], may provide a spiritual link between art and science. Yamantaka, or 'the one who terminates Yama', is considered as a Dharmapala, a protector of the teaching. He overcomes the deity of death, Yama. Obviously, he is an important figure in the context of Buddhist death rituals. His great power is expressed by his nine heads, thirty-four arms, and eight legs. He tramples with his feet on mortal beings, animals and humans. He is surrounded by red flames which destroy all evil. His thirty-four hands carry symbolic objects which represent his powerful features. Among them, one finds the hook (ankusa), the three jewels (triratna), the ritual wand (khatvanga), the double skull drum (damaru), the bow (capa), and many others, each having its own special meaning. The central bull head, he has in common with Yama. He carries seven more frightful heads, all of them with a third mystic eye. But the ninth top head has a peaceful expression. It represents Manjusri, the Bodhisattva of wisdom. In fact, Yamantaka is considered as an emanation of Manjusri who is a protector of Tibet [22]. Actually, Manjusri is shown just above the Yamantaka heads. He carries in his left hand the book of wisdom and in his right, he swings a sword cutting through the clouds of ignorance.

It is remarkable that wisdom and conquering death are put in a close context. This view closely matches the scientist's philosophy, who strives for immortality by publishing immortal truths which hopefully will survive the discoverer by many centuries. Indeed, a strong motivation for scientific activities is the creation of lasting monuments. In science also wisdom tries to conquer death.



Fig. 8a. Tibetan thangka of the yidam Yamantaka, the conqueror of death. He is an emanation of the Bodhisattva of wisdom, Manjusri. He is surrounded by a (Sakya?) lineage in the upper half and the ten deities of the directions on their symbolic animals on the lower left and right sides, some representations of Yama at the lower edge with Vajrapani in the lower center, with sun and moon deities at the lower left side, together with a celebrating monk in the lower left corner. 15th century. 90 x 82 cm.

The frightful emanation of a peaceful Bodhisattva visualizes a deep truth of eastern, and in particular Buddhist philosophy [11–15]. Expressed often in the form of the Yin-Yang symbol, it symbolizes the connectedness of the spiritual world where 'good' and 'bad' are aspects of the same profound truth, and where the two terms cannot as easily be antithetically separated as we in the west often pretend. Correspondingly, many Tibetan deities and deified historical persons may appear in their peaceful or frightful aspects, often in the same painting.

In the top row, one finds the blue Adibuddha Vajradhara (left from the center), a further blue Buddha, four Indian mahasiddhas, a yellow lay person, and five Tibetan monks. In the far left and

right columns, there are further monks, the ten deities of the directions on their symbolic animals, and on the lower left the deity of the red sun (Rakta Aditya) and of the white moon (Sita Candra). The monk at the lower left corner performs the ritual of Yamantaka. In the lower center, one finds the Bodhisattva Vajrapani, surrounded by further companions of Yamantaka.

The powerful Yamantaka painting is likely to originate from southern central Tibet. The dominance of the red cinnabar suggests a connection to early Nepalese painting schools which strongly influenced Tibetan painting between the 11th and 15th centuries. Based on stylistic reasoning, one would date the painting around 1400, as suggested by the previ-



Fig. 8b. Detail from Fig. 8a with the nine heads of Yamantaka of which the top head belongs to Manjusri who is shown in full in the center above with the book of wisdom in his left and a sword in his right to cut through the clouds of ignorance. 37 x 29 cm.

ously mentioned golden triangles behind most of the figures, by the execution of the arch in each individual icon and by their strict geometric arrangement, giving a mandala-like impression. The inscriptions along the lower edge and on the reverse side do not provide much insight into the date of origin. ^{14}C dating led to the period 1472–1648 [66]. The earliest date compatible with the ^{14}C data is 70 years later than the stylistic estimate. A late 15th century date could be acceptable but the proposal of a 16th or 17th century date would offend most ‘thangka experts’; they trust their stylistic feeling better.

5. Kalachakra Mandala

Mandalas are feasts of symmetries and broken symmetries [84][85]. They

attempt a comprehensive representation of the spiritual universe. In this sense, they have similar ambitions as elementary particle physicists and cosmologists trying to understand the most inner workings of nature. They are centered on a venerated deity. The mandalas serve as meditational aids in focusing one’s attention sequentially on deeper and deeper aspects of the deity, progressing mentally from the periphery to the center of the mandala.

Often, mandalas are intimately connected with one or the other of the great Tibetan (or originally Indian) tantras, each providing a particular pathway of redemption under the guidance of a knowledgeable Sadhaka or teacher. The name figure of a tantra is a virtual deity, called a Sadhita. Sadhitas have, according to the Buddhist dogma, no real existence but are invoked only in the course of

a meditational procedure. They become a spiritual reality exclusively for the meditating person.

The mandala, shown in Fig. 9a, published in [7] and [86], represents a most important and also most complex Kalachakra (‘wheel of time’) tantra which attempts to unify space and time [87], a goal remotely similar to modern physics. It forms the culmination of a series of 26 mandalas forming the Vajravali tantric liturgy written in the 11th century by the Indian sage Abhayakaragupta [88]. The Kalachakra rite is also regularly celebrated by the 14th Dalai Lama. The rather small-sized mandala is extremely finely executed in its detailing and requires much magnification for a careful study. The central 24-armed and four-faced deity Kalachakra is shown enlarged in Fig 9b, embracing his eight-armed female consort Vishvamata.



Fig. 9a. Kalachakra mandala painted, according to an inscription, at the central Tibetan monastery of Ngor in honor of the deceased 11th abbot Sangye Senge (1535–1569) and commissioned by the 13th abbot of Ngor, Namkha Pelzang (1535–1602). Painted after 1569. 54.6 x 49.5 cm.

The meditator experiences the mandala starting from the periphery. The outside ring is called the ‘burning ground enclosure’, consisting of a circle of flames, a representation of the eight Indian mystical cemeteries and a lotus circle. This is the first hurdle which the meditator has to overcome. The four differently colored quadrants represent the four elements: air, water, fire, and soil. Inside follows the great body-mandala palace (Kaya-mandala) with four huge doors occupied by guardians. This palace contains twelve very tiny mandalas, executed in all details, representing the twelve months, each characterized by an animal. The next inner square represents the speech-mandala palace (Vacmandala), again with eight doors and with eight even tinier mandalas. Then follows the mind-mandala palace of similar design. A further square filled with tantric repre-

sentations of the transcendent Buddhas and a circle with eight eight-armed Shakti deities finally lead the meditator to the central Kalachakra.

The origin of this extraordinary mandala can be localized and dated based on an inscription at the lower edge [89]. It was painted in the famous Ngor monastery near Shigatse, commissioned by the 13th abbot Namkha Pelzang (1535–1569) in honor of the deceased 11th abbot Sangye Senge (1504–1569) [62] and must therefore have been painted in the early 1570s. The Sakyapa Ngor monastery had at that time already a long tradition in the creation of highest quality mandalas and other thangkas. Fortunately, many master pieces have found their way into the west, while the monastery itself was completely destroyed under the command of the ‘peace-loving’ Chinese intruders.

6. A Nepalese Paubha Laksha-chaitya

Although the enormously large Tibetan empire of the early period between 700 and 800 could not be maintained for long, the Tibetan Buddhist influence survived in a wide area extending from Ladakh to Beijing and from Nepal to Buria-tia. Thangkas are known that originate from all these regions. In Nepal, a characteristic, highly refined painting style has persisted up to present times. Buddhist and Hindu paintings exist here side by side and have cross-fertilized each other during centuries of coexistence [58–60]. The paintings are here called ‘paubhas’.

A particularly beautiful, ancient Nepalese paubha is presented in Fig. 10 [90]. It was commissioned on the occasion of the performance of a Laksha-chaitya rite. Special merits can be ac-



Fig. 9b. Detail of the Kalachakra mandala of Fig. 9a showing Kalachakra together with Vishvamata in yab-yum, surrounded by eight shakti deities. 9.6 x 7.8 cm.

quired, according to an old Nepalese tradition when one hundred thousand (laksha) stupas (chaitya) are dedicated to a deity. This was normally done symbolically by a painting showing many (instead of a hundred thousand) small chaityas [60]. Nepalese paintings often display at the bottom the family of donors with men on the left and women on the right. Stylistically, one can date the painting to between 1350 and 1500. In Nepal, even more than in Tibet, traditional styles have been maintained for long periods.

In many Nepalese paintings, an inscription indicates both the date and the names of the donors. In our painting, the date at the beginning of the inscription is damaged and cannot be read by eye or magnifying glass. However with an infrared camera one can decipher the three

digit number: 568. As the Nepalese time zero is the year 880, the painting was consecrated in 1448. The inscription also mentions "...during the reign of the King of Kings Sri Sri Jaya Jaya Malladeva..." [91]. A king of this name is historically not documented. Actually, from 1428 to 1482, King Jaya Jaksa Malladeva reigned [92]. Perhaps a single syllable was misprinted or, perhaps, the repetition of 'Jaya' was used in his colloquial Newari name. Perhaps, the repetition refers to the fact that, initially, the King reigned together with his younger brother Jaya Jiva Malladeva (who died in 1447) [92]. Also the names of the donors and, a rare event, even the names of the artists who worked on this paubha are mentioned.

A recent ^{14}C analysis [66] led to the surprise that the sampled cotton appears

to have been produced much later: between 1688–1733, 1812–1926, or even 1954–1956! Taking into account the extremely skilful painting, the unique subject, not likely to be copied, the obviously aged cotton, and the 'aging' damages, it is highly improbable that the paubha was produced or copied during the 19th or 20th century. However, it is known that the painting has recently been restored. Although care has been taken to sample the original unaffected cotton, it could be that some recent material has contaminated the sample. Often, the edges of a thangka are the most worn and are the first to be restored, without much danger of damaging the painting itself. It is likely that some restored material has been sampled. It becomes clear that, in general, ^{14}C data of thangkas have to be interpreted with great caution.

Nepalese painters apply somewhat different pigments and binders than the Tibetan ones. Malachite and azurite are rarely used for green and blue, respectively. Mostly, a blue paint is obtained by mixing indigo with some whitening material, such as chalk or kaolin. The green is produced by mixing indigo with orpiment (As_2S_3) or perhaps Indian yellow (a magnesium or calcium salt of euxanthinic acid) [93]. The binder receives often an oily component, and the paint resembles sometimes egg tempera with more glaze than Tibetan paintings. Nepalese paintings are somewhat less sensitive to water damage. Nevertheless, fewer early Nepalese paintings have survived because the hot, humid climate in the Katmandu valley disfavors their preservation.

The paubha was executed on cotton, covered with a gesso consisting of gypsum. A rather restricted set of pigments has been used. All blue shades are derived from indigo. Neither azurite nor malachite was applied. The green is a mixture of indigo and orpiment. The latter is also the pigment for the yellow areas. In addition the heavy usage of carbon black gives the painting a solid and definite appearance.

Arts and Sciences, Concluding Remarks

Conservation and restoration of precious art works is as demanding as the practice of medicine, perhaps even more so. While a human being is to a remarkable degree error-tolerant (otherwise most medical practitioners would have lost their jobs by now), art works can easily



Fig. 10. Nepalese Buddhist paubha consecrated for the Laksa-caitya ('hundred thousand stupas') rite, showing Buddha Sakyamuni together with the Bodhisattvas Vajrapani (blue) and Padmapani (orange) within the central stupa, surrounded by 488 small stupas. The top row presents seven forms of Buddha. The lowest row contains from the left the donor and a priest performing the vajracharya rite, three of the seven jewels (saptaratna): elephant, wheel, and minister, a four-arm form of the Dharmapala Mahakala in a variant representing the protector of science [20], four further jewels: queen, horse, jewel, and warrior; and female companions. Dated 1448. 86 x 60 cm.

be damaged irreversibly. The more scientific knowledge on the art work to be conserved is available, the safer and better adapted a treatment can be performed. Chemistry is indeed of central importance in the analytical preparation of the conservator's work. It is of even greater importance in the actual conservation and restoration process, which has not been touched upon in this brief essay.

For the author, art has been a constant source of inspiration in his professional research work. Perhaps art has contributed more than science to make our world hospitable and lovable, although science is of greatest importance for our survival. Together, in a creative symbiosis, they give us hope for a prosperous future in view of our physical and emotional well-being.

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