PART 3

Exploring the Materiality of Prints and Manuscripts

Wooden Book-covers, Printing Blocks, their Identification and Dating – How to Read the Wood

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Wood is a unique material which is able to retain in its structure messages from the past. Woody plants, including trees, produce in each growing season a new layer of wood, which can be distinguished from the wood produced previously. Pallardy (2008, 2) has described trees as “complex biochemical factories that grow from seeds and literally build themselves”. Growth takes place periodically, mostly on an annual basis. The life of a tree is controlled by its environment, and environmental factors responsible for it: whether the year or season was favorable for growth or not, are registered and saved in anatomical structure. Therefore wood is called a “biological archive” (Eckstein 1986) or “biological time capsule” (Baillie 1995).

Wood can survive as an engineering material or in the form of wooden products for hundreds and thousands of years. Anatolian grave chambers (Kuniholm et al. 2011) or Early Neolithic wells in Europe (Tegel et al. 2012) are the best examples. They all contain numerous historical data written in the wood’s structure. The cultural heritage of Asia has enormous potential as yet undiscovered. Wood as a material used for printing will help us to date and to understand printing technology, technological advances and history of particular objects and texts. Concomitantly, important climatological information may be extracted from the wood structure which can enhance our knowledge of socio-cultural processes in relation to the environment.

The high mountains of Central Asia, part of the landmass which we will call High Asia, is a region known as the target of the Indian and East Asian monsoons which supply a large part of the continent with rainfall. In these high mountains, a variety of cultures and religions are to be found. People living in these harsh conditions were dependent on trees for fuel, material to build houses, shrines, and temples, as well as food for their livestock. The importance of wood was emphasized by its shortage. This contributed to the development of a wood-dependent culture spreading from craft centers, such as the Kathmandu Valley, along and across the Tibetan Plateau.

FIGURE 20.1 Cross-section of Himalayan birch (*Betula utilis*). Diagonal lines are tree-ring boundaries. Arrow shows growth direction. Scale bar is 2 mm long. (Fot. Eryuan Liang).

These high altitude areas are home to groups of people living at the limits of existence. Dating their technological advances and considering socio-economic aspects provide a unique source of information about environmental changes. Wood was one of the main building materials, and all villages, abandoned settlements, barns, temple sites, forgotten ways and forts, ruined bridges (within their contexts) are just as important sources of information as the time series. Structural timber, artifacts and wood from archaeological sites offer also the possibility of contributing to the knowledge of the local vegetation history.

Even a cursory look at a fragment of a cross-section of a Himalayan birch tree, a species common in the upper parts of the Himalayas, manifests similarities to bar code labels (see Fig. 20.1). The line pattern of this particular tree shows that it was slowly but regularly growing for many years until it underwent an unfavorable period of 16 years. The tip of the arrow shows the beginning of this period. The stress that the tree survived was so deep that the tree was not able to produce the new layer of wooden tissue over its whole circumference in the middle of this period. The occurrence of such so-called “missing rings” indicates dry and warm pre-monsoon seasons (Liang et al. 2014). It means that we are reading a history of a long pre-monsoon drought in the Himalayas with annual resolution.

This example shows that wood has enormous informative potential which has yet to be fully tapped into in relation to Tibet. By identifying this kind of material, we learn about the woods used for production, their origin and the regions supplying the workshops, and their suitability for advanced

examination, for example dendrochronology. Wood properties and the natural durability of wood will provide suggestions concerning optimal protection and conservation methods. Species suitable for dendrochronology provide a unique chance for precise dating and environmental information in addition. Thus – what are the woodblocks and covers made of?

To answer this question let take a closer look at the materials that were available to artisans and were most suitable for Buddhist scriptures. Which wood species could be expected in High Asia? Mountains collecting monsoon precipitation are regions especially rich in forest resources. The upper timberline is located at an altitude of up to 4500 m a.s.l. High mountain forests are far better preserved on account of their relative inaccessibility, than, for example, the Hill Regions of Nepal which are heavily deforested. Forest composition may be briefly presented in the following way:

- In the Himalayan region, including inner Himalayan valleys, the following species are dominant: east Himalayan fir (*Abies spectabilis*), blue pine (*Pinus wallichiana*), West Himalayan spruce (*Picea smithiana*), oak species yielding hard wood and fodder (mainly *Quercus semecarpifolia* and *Quercus glauca*) and precious Himalayan cedar (*Cedrus deodara*) the occurrence of which is limited to western parts of the Himalayas.
- In the vicinity of Lhasa, fast growing poplar (*Populus*) is present, but the quality of the poplar wood is rather poor. Junipers (*Juniperus*) and pines (*Pinus*) are also present there but in lesser quantities.
- In northeastern parts of the Tibetan Plateau Quillian juniper (*Juniperus przewalskii*) is well represented.
- Less arid, eastern Tibet and western Sichuan are partly covered by forests with different species of fir (*Abies*), larch (*Larix*), spruce (*Picea*), juniper (*Juniperus*), cypress (*Cupressus*), and Himalayan hemlock (*Tsuga dumosa*) trees. Clear-cut coniferous forest was replaced in a short time by broadleaf species or slopes were degraded by erosion processes.
- Forests in Bhutan contain spruce (*Picea*), Himalayan hemlock (*Tsuga dumosa*), Himalayan larch (*Larix griffithiana*), Chir pine (*Pinus roxburgii*) and blue pine (*Pinus wallichiana*).
- In addition, a wide variety of tropical and sub-tropical timbers could be imported from India, southern Nepal, Burma and southern provinces of China.

The present forest composition corresponds only partly to the forest from the past due to periods of deforestation and following regeneration. Changing climate conditions also shaped the vegetation – we can still find remnants of

coniferous forest from the coldest phase of the Little Ice Age (17th c.) invaded by broadleaf trees after climate became warmer.

The determination of wood species is possible by means of microscopic techniques. Samples in the form of small splinters of wood are usually sufficient to prepare thin sections representing the transverse, tangential and radial directions. In situations when sampling is not possible, microslides, 0.01–0.02 mm thick, can be done directly on the object which would not leave any visible traces. The microslides are observed under a biological microscope in transmitted light (Map 20.1) and compared with reference materials. Identification at the level of genera and sometimes species is possible in this way by experienced wood scientists. This information combined with maps illustrating the range of natural distribution of identified genus/species will indicate the potential region of origin.

Tree-ring structure visible at the cross-section and sometimes at the radial section of wooden objects may be the subject of dendrochronological examination. Dendrochronology is one of the most important analytical methods used for the study of cultural heritage objects. Well-known as the most precise dating method, dendrochronology also provides information about the origin of the timbers. By comparing an undated tree-ring series (i.e., sequence of growth-rings from a wooden sample) with absolutely dated master chronologies from the same species and same geographical area, an exact calendar year can be assigned to each ring in the examined sample. Thus, the history of construction, renovations, and major structural changes can be dated with annual, and sometimes sub-annual, precision. The dating accuracy depends on the preservation of the youngest rings – those from the outer part of the tree. Annual precision can be achieved only when the youngest (outermost) rings are present – the last rings created by the tree before it was cut down.

Successful dendrochronological dating depends on the availability of master chronologies for the area of interest. The International Tree-Ring Data Bank housed in the National Climatic Data Center in Asheville, North Carolina, USA, is the only source of data for tree-ring research available to scientists. In 2014 the ITRDB contained nearly 160 tree-ring chronologies representing the Tibetan Plateau and regions surrounding Tibet. 42 of them represent Nepal, 40 – Pakistan, 35 – China, 22 – India and 20 – Bhutan. The geographical distribution of tree-ring chronologies is shown on the map (Map 20.1).

Triangles marking locations of chronologies form a kind of a garland around the part of the Tibetan Plateau. The interior remains empty. Natural forest resources in that area are very limited but information from the past is preserved in the historical timbers of building structures, furniture, sculptures,

MAP 20.1 *Satellite map with position of tree-ring chronologies (green triangles) in High Asia.*

SOURCE: WORLD DATA CENTER FOR PALEOCLIMATOLOGY, NATIONAL CLIMATIC DATA CENTER (NCDC), ASHEVILLE, NORTH CAROLINA, USA.

book covers, etc. Subterranean tombs of Dulan with huge quantities of juniper wood used in the form of unworked trunks to cover tomb chambers and the construction of block-house type structures (Sheppard et al. 2004) are the best examples.

Tree-ring chronologies represent almost exclusively conifers: 5 fir species, 5 spruce species, 4 junipers, 3 pines and single species of cedar (Himalayan cedar), Himalayan hemlock, *Cupressus chengiana* (no English common name) and Siberian larch. All these chronologies were developed for reasons of climate study, climate reconstruction, forest productivity, hydrology, glaciology, etc., and they are based on data derived from living trees. There are a few historic tree-ring chronologies developed from old buildings (Brauning 2013, Schmidt et al. 1999, Schmidt et al. 2001) and archaeological timbers (Sheppard et al. 2004), but the data is unpublished. Blue pine (*Pinus wallichiana*) – the most sought after wood for buildings in the mountains – is represented in ITRDB only by 6 chronologies from Nepal, Pakistan and Bhutan. On the other hand 24 chronologies were developed for the East Himalayan fir (*Abies spectabilis*), less appreciated as timber.

The longest combined chronology (living trees and archaeological material) goes back to 515 BCE and was constructed from junipers (Sheppard et al. 2004).

FIGURE 20.2 *Number of tree-ring chronologies developed for High Asia in selected time-windows.*

The period before 1500 CE is represented in the ITRDB resources by 47 chronologies, and before 1000 CE – by 7 tree-ring chronologies (fig. 20.2). Most of them represent junipers – trees which can be extraordinarily resistant and old. In some areas, especially semi-arid areas, only junipers were available.

A fortification in Lupra in Southern Mustang, Nepal (Fig. 20.3) is an example of the successful dendrochronological dating of an historical structure from an area without trees.

The Panda Khola Valley, a narrow eastern branch of the Kali-Gandaki Valley in Mustang, leads to the remote village of Lupra, which became noteworthy for the first time over 800 years ago – its first monastery was founded around 1160 by Bon missionaries (Ramble 1984). A modest village today, it has nearly 100 inhabitants. The ruins of an old castle or fort dominate the northern slope above the village, witness to the prosperity of old Mustang and the Salt Route leading from Tibet across the Himalayas to India. This structure in Lupra is classified as an observation tower/fortress. It belongs to the well-developed chain of castles and castle-like buildings constructed to control access to valleys, to protect local duchies and to collect taxes from trade caravans (Seber 1994). This structure in Lupra, with its three-storey tower, had a few other castles and observation towers in direct sight, some of them far away but close enough to transmit light or smoke signals.

Today, the structure's tower in Lupra is ruined. The original wooden construction inside the building doesn't exist, but visible in the walls are the beam-holes, still containing the ends of beams from the time of construction (Fig. 20.3). These provided excellent material for the tree-ring study. Most of

FIGURE 20.3 rDzong in Lupra.

the beams were made of pine, and the only pine in this geographical region is *Pinus wallichiana*. A well replicated reference chronology for blue pine from the Lower Mustang was already developed at the time of sampling (Schmidt et al. 1999) and examination of samples collected from the fortification yielded 11 dating results (fig. 20.4). Seven samples were dated with annual precision. This means that we know precisely the calendar year when the tree was cut. These precious trees were cut intentionally; thus these dates indicate unequivocally the time of construction. The concentration of results within a short time-interval of 4 years excludes the possibility of the utilization of reused timbers, although it should be noted that the reuse of timber was a common practice in these wood-poor regions of Asia – timber may therefore not always be used to date a structure, as the timber may predate the structure (Baatarbileg et al. 2008). The collection of a larger number of samples is required to avoid this problem, as well as the problem of the accidental dating of younger replacements. This would increase also the possibilities of interpretation of samples without their youngest rings preserved.

The trees used for the construction of the structure at Lupra were cut in the years 1589–1592. Taking into consideration the transportation and processing time, we can determine that the structure was built in 1590–1593. In that time the area south of Kagbeni, near Lupra, was controlled by the kingdom of Jumla. The timber came from 80–120-year old pine trees.

FIGURE 20.4 *Dating the growth sequences of remnants of pine beams found in walls of the structure (a castle/fort with a tower) in Lupra, southern Mustang. Bars are showing position of tree-ring series representing sample with given number in time.*

Apart from buildings, wood is also importantly present in printing and the technology of the book in High Asia, mainly in the form of xylographic blocks and book covers. In contrast to the “Western World”, xylography has played an important role over centuries there, because movable types were never developed in Tibet (Helman-Wazny 2014).

Xylographic blocks were introduced in Buddhist Asia several centuries before they were in Europe. The earliest known examples are from 8th c. Korea and Japan (Helman-Ważny 2014, 117). In case of Tibet, the 12th century is regarded as the period when block-printing technology was introduced (Schaeffer 2009, 9). Wood selected for printing blocks must have properties appropriate for this application: hardness, low abrasiveness and structure, allowing it to obtain and retain high precision shapes. At the same time it should have a uniform structure and a reduced tendency to crack. The most sought after timbers for printing blocks were pear, jojoba, and, closer to tropical regions, shorea, sal, and sandalwood (Helman-Ważny 2014, 127). Areas poor in wood were, however, much more dependent on local resources due to economic reasons.

The numbers – 42000 “printing blocks engraved on both sides” prepared to print Kanjur, part of Tibetan religious canon (Helman-Ważny 2014, 129), or 81258 wood blocks used for the second version of the Korean Tripitaka

FIGURE 20.5 *Used wooden block print from the Library of Tibetan Archives in Dharamsala after printing hundreds of copies.*

(Park 2014, 12) – give an impression of the wood quantities required by printing houses. In the Himalayas, since mainly coniferous species are available, this wood was often used. At higher altitudes in the mountains, printing blocks were frequently made of Himalayan birch (*Betula utilis*) (Diemberger 2014, pers. comm.). Birch in Europe is regarded as a low quality wood, used for the production of plywood, pulp and paper industry, or invisible furniture pieces. The slow growing Himalayan birch, however, has very hard wood and, in the absence of higher quality wood, could be used as a main material for printing blocks. Similar criteria for wood selection were applied in Korea. Since pear and jojoba, widely used in Chinese xylography, were difficult to obtain in the Korean Peninsula, the local birch (*Betula Schmidtii*) became the main type of wood used for the carving of printing blocks (Park 2014, 13).

Himalayan birch is a widespread broadleaf timberline species which grows between 3000 and 4200 m. Birch is well known because of its white bark which was used as writing material before the introduction of paper. Birch trees covering large areas in the Himalayan region are of a medium size. The dominant trees from Sagarmatha National Park selected for the tree-ring studies were of 50–80 cm diameter (Liang et al. 2014). The number of copies printed from a single xylographic block is difficult to calculate and rough estimates range from hundreds to thousands (fig. 20.5). For that reason the availability of material seems to be very important. This also explains the utilization of just this type of wood.

Birch has been a subject of dendroclimatological studies and revealed to be suitable for dendrochronology (Bhattacharyya et al. 2006, Davadi et al. 2013, Liang et al. 2014). The maximum age of the trees can be more than 400 years; thus a tree-ring chronology based only on living trees may reach to the end of 16th c. For successful dating, however, around 50 or more rings on the cross-section of wooden block should be accessible. The mean ring-width of 211 trees from Sagarmatha National Park in Nepal was 0.81 ± 0.53 mm (Liang et al. 2014). This means that a 14 cm wide and radially cut board made of slow growing birch may have 150 or more rings.

Book covers of Tibetan books are different from those of Western books. Tibetan books, even today, generally have the traditional, loose-leaf form. The stack of unbound pages is simply placed between a pair of wooden boards which play a similar role to Western book-covers though the leaves are not bound to the boards (Fig. 20.1). The boards may be plain, painted and/or carved and richly decorated, sometimes gilded or lacquered. The size of the book-covers depends on the size of the paper sheets and can even reach “a size of a door”. The largest known book is 130x170 cm and is owned by Sa skya monastery (Grönbold 1991, 10). The upper board has metal rings and must be lifted by four monks.

The selection of wood depended in general on what was available in the region. Areas poor in wood were supplied by the south and southeastern regions of Tibet, Nepal, Bhutan, or eastern India. The availability of heavy tropical timbers (the best material for stable book covers) and the thickness of wood used was limited by the cost of transportation over the Himalayan passes (Selig Brown 2012, 16). There was thus a difference between the desirable and the available materials. The results of wood identification reveal what was actually used. For instance, an examination of 13 covers of Buddhist manuscripts from the collection of the Asia and Pacific Museum in Warsaw, Poland revealed that four covers were made of blue pine (*Pinus wallichiana*) growing in the mountains above 2000 m a.s.l.; one book cover was cut of chir pine (*Pinus roxburgii*) the distribution of which is limited to elevation 400–2300 m a.s.l., and this species occurs e.g. in Kathmandu Valley; two other book covers were made of *Trema politoria*, a species characteristic of the foothill forests of Nepal, northern India, Kashmir, and Pakistan; further, one book was covered with boards made of *Semiliquidambar cathayensis* – a species endemic to China. Five covers were not identified. Pine wood was distinctly dominating.

The Tibetan “Book of the Dead” from the British Library (OR15190) was selected to test the possibility of applying wood science in the study of the printing heritage of Asia. The upper cover of the book was made of a wooden plank, 50 × 21 cm, and 1.5–1.8 cm thick. The plank was made of coniferous wood and cut radially (fig. 20.6). This method of trunk conversion (radial cut) secures

FIGURE 20.6 *'The Book of Death,' British Library OR15190, upper cover with visible wood texture and tree rings.*

the shape stability of the plank and maximal number of available tree-rings, because the cut line ran perpendicular to tree-ring boundaries.

The first step of investigation was microscopic wood identification. Microslices representing the axial, radial, and tangential samples were prepared. Identification was based on observation under a biological microscope in transmitted light. Magnification at 50×, 100× and 200× was applied. The microscopic picture (Fig. 20.7) was compared with reference materials and the wood atlas. The details of the wood's anatomical structure revealed that the examined plank was made of spruce (*Picea sp.*). This genus is represented in the Himalayas, Karakorum, Tian Shan, and in south-eastern Tibet only, which reduced the area of possible origin significantly.

The tree was at least 150 years old. A measurement of ring widths yielded a tree-ring sequence that was 142 years long. The tree-ring series displayed in fig. 20.8, and illustrating the rhythm of the growth of the tree, shows two periods of growth reduction which occurred in relative years 32–45 and 104–124. They probably reflect changes in climatic conditions.

A comparison with available tree-ring chronologies was not successful and I have not obtained any secure dating results yet. However, it is expected that an increasingly dense network of tree-ring chronologies developed for spruce in particular will lead to the absolute dating of the book cover.

The examples presented above demonstrate the role of wood – definitely an underestimated subject of historical study – as a witness of the past. This

FIGURE 20.7 *'The Book of Death', British Library OR15190, upper cover, tangential section in magnification 100 $\times$.*

FIGURE 20.8 *Tree-ring series representing "The Book of Death", OR15190, British Library. X-axis represents relative years, Y-axis – tree-ring widths in hundreds of mm in logarithmic scale. Value "100" means 1 mm.*

is one of the first attempts to apply wood science to the study of the “printed heritage” of Tibet and beyond. To achieve significant progress in this field in the foreseeable future, certain conditions should be fulfilled. The following are the most urgent:

1. Development of annual, precisely dated series of ring width from the long-lived trees combined with tree-ring series obtained from historic buildings and archaeological timbers will provide precise dates for historical objects.
2. Systematic identification of wood species used for book covers and printing blocks is required.
3. Sources of old timbers and tree-rings are rapidly disappearing without being investigated. This process is irreversible!

The proposed ‘pairing’ of Asian studies and wood science cuts across many borders, between disciplines and sub-disciplines. Like our predecessors exploring High Asia, I feel the thrill of stepping into new territory.

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