Wood identification of cultural artifacts
－a combined use of synchrotron X-ray microtomography and optical microscopy techniques－

**(Graduate School of Agriculture,
Laboratory of Biomass Morphogenesis and Information, RISH, Kyoto University)**

Suyako Tazuru-Mizuno

Wood identification is an effective practice in the fields of archaeology, commerce, art history, architecture, and ethnological study, among others. The anatomical features of many wood species have been described for wood identification. In general, the identification of wood requires the observation of its microstructure from three directions: axial, radial, and tangential. One method involves the use of a razor blade to take a thin slice from the wood blocks and to then prepare microscopic specimens to determine the three directions. Although this method becomes simple after training and experience, it is not applicable in cases in which only a very small sample is available, as is always the case for wood works or artifacts that are part of the national heritage. Furthermore, the wood samples that have fallen off of such artifacts are often too brittle and soft because of their degradation as a result of biological attack or many other factors. Against this background, we can see that the development of alternative methods of identification is desirable. The requirements for such alternative means are that they must be nondestructive, rapid, accurate, and reproducible. A computed tomography technique (CT) is thought to be one of the best approaches. In the field of wood anatomy, CT has been used, but because the resolution is low, it is only applied to the investigation of tree rings. In this study, Synchrotron X-ray microtomography (μ-CT) at a synchrotron radiation facility (SPring-8), which is non-destructive of nature and has ultra high resolution (<0.5μm), was applied especially for the analysis of small and important artifacts (Fig 1).

In Chapter 2, the μ-CT, which makes possible the non-destructive investigation of 3D microstructures was applied to the identification of the wood of a historical wooden sculpture Seshin-bosatsu statue, a historical brittle wooden mask discovered in Kumamoto Prefecture, Japan (Fig 2), and old wooden sculpture Shinzo excavated from the Shiozuko site in Shiga Prefecture. These flaked samples of wooden cultural assets are quite small and compressed, and display insect damage and high moisture content. Using a μ-CT dataset, typical reconstituted slices from the three major directions of wood are prepared. Unlike optical micrographs, each reconstituted slice was only 0.5 μm thick, which made it necessary to increase the depth information. For this purpose, 24 slices were integrated to prepare pseudo-micrographs that were 12 μm thick using Image J software. This allowed us to apply wood anatomical features from the literature to the data obtained by synchrotron X-ray microtomography. Thus, Synchrotron X-ray microtomography methods have a tremendous potential. Because of its nondestructive character, the identified samples can be used further for chemical analysis, such as component analysis.

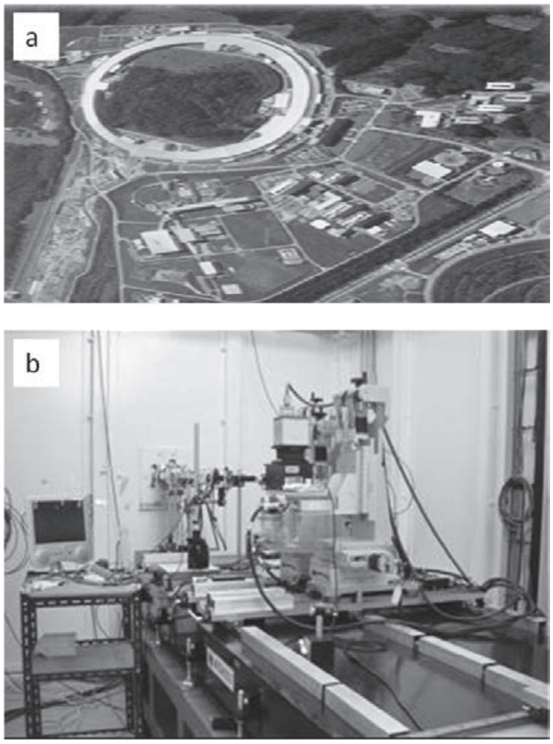

Fig 1: Bird-eye view of SPring-8 (a) and appearance of beam line 20XU (b).

In Chapter 3, wooden cultural assets that include many wooden sculptures were investigated in the same way. Recent study shows that in the 7th century, *Cinnamomum camphora* was basically used for wooden statues, while wooden statues of the 8th century were made of *Torreya nucifera*. However, for comparison with Buddha statues, the wood species and wood selection criteria used for Shinzo and Komainu have not thus far been adequately investigated. In Chapter 3, the author tries to identify wood species using synchrotron X-ray microtomography without causing any damage to the statues themselves. It is revealed that wooden statues of Shinzo and Komainu were mostly made of *Torreya nucifera* (Fig 3) and *Chamaecyparis obtusa*.

In Chapter 4, the author anatomically identifies the wood species in the Chion-in temple, Zuigenji temple, Myoutsuji temple, Yasaka shrine, Maruoka castle, Konchi-in tearoom, and Housyusya tearoom. Tiny samples from the disarticulation are useful for the identification of original wood. Wood identification is necessary not only in the investigation of original wood, but also in other research investigations, such as the value of a building, the purpose of an architectural feature, the transitions of building materials, and the regional characteristics of building materials. Moreover, wood identification has other significance for historical research. The books describing adequately the earliest construction work and restoration have sometimes been found. In order to confirm the descriptions of such historical data, wood identification also has a special meaning.

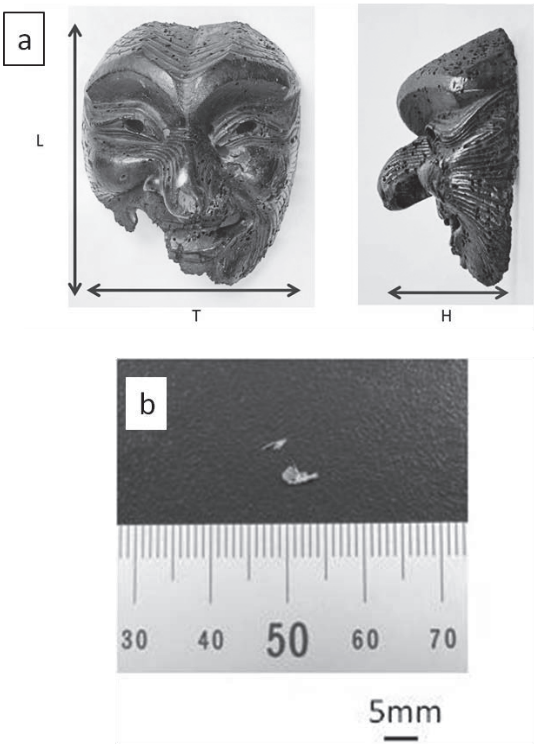

Fig 2: The old wooden mask (a) discovered at Yatsushiro city, Kumamoto, Japan. It was painted with black lacquer. (b) Small fragments were inevitably flaked off. Courtesy of Yatsushiro Municipal Museum.

Wood identification is also effective in the field of archaeology. For example, determining tree species has helped us to understand the selection of wood in terms of wooden artifacts, vegetation, history, and other areas. Many and various woody remains have been excavated from many sites in Japan. Recently, the wood selected for several wooden artifacts in the past has been clarified by many scientists. Wood identification has also contributed to the determination of the wood selection process. In Chapter 5, the author identifies the anatomy of the wood species of about 400 woody remains originating from a shrine construction excavated from the Shiozu site (Heian era), Shiga prefecture. Based upon these identified results, the characteristics of wood selection used for shrine construction in the past environment of Shiga prefecture are discussed.

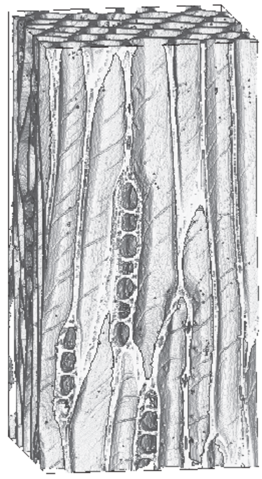

Fig 3: Typical 3D rendering of *Torreya nucifera* constructed using synchrotron microtomography dataset.

Acknowledgements

The author wishes to express her sincerest thanks to professor Junji Sugiyama, Research Institute for Sustainable Humanosphere, Kyoto University, for his kindest guidance and encouragement during the entire course of this study. The author wish to express special thanks to Shuichi Kawai, a professor at Research Institute for Sustainable Humanosphere Kyoto University and Keiji Takabe a professor at Kyoto University for their kindest guidance.