

Identification of wood of archaeological heritages by X-ray micro-CT imaging

The identification of wood of archaeological heritages has provided useful information on the origin of the heritages and sometimes provided a new perspective. Wood identification at the genus level requires the observation of microscopic faces from 3 directions, namely, the transverse, radial, and tangential directions. One method involves using a razor blade for making a thin slice from the wood blocks and then preparing microscopy specimens for the 3 directions. Nevertheless, this method becomes routine after training and experience, but it is not applicable to cases in which only a very small sample is available as is always the case for wood works or artifacts of national heritage class. Furthermore, wood samples are often too brittle to use for microscopy preparations owing to biological attack or degradation. In this study, therefore, synchrotron X-ray micro-tomography, which enables the nondestructive investigation of 3D microstructures was applied [1]. Synchrotron X-ray micro-CT imaging at **BL20XU** provides a resolution of 0.5 μm , which sufficient for visualizing most of the species-specific anatomical features necessary for the identification of wood. We describe an example of applications of this technique to the investigation of a wooden mask below.

In 2008, an old wooden mask shown in Fig. 1 was discovered at Yatsushiro City, Kumamoto Prefecture, Japan. This mask has been handed down from the end of the 16th century; a Japanese soldier brought it from the Korean Peninsula during the war between Japan and Korea in the 16th century.

According to the ancient book named "Higokokushi," written in the middle of the 18th century, a Japanese farmer went to the Korean Peninsula as a soldier with Yukinaga Konishi in the 16th century, and after the war, he brought a large mask to Kumamoto Prefecture. Later, when it was discovered, it was suspected that this mask could be a proof of the historical interaction between Korea and Japan. It is known that the Korean people would hold masquerade parties in ancient times. However, only a few old wooden masks are conserved because masks were allegedly burnt after the ceremony. The most famous masks in Korea are the Hahoe masks: 11 Hahoe masks of the Korai era (around the 14th century) have been conserved in the Hahoe village. They were all registered as national treasures in 1964 and are currently kept by the National Central Museum in Korea. According to Park (2005) [2], all the Hahoe masks were made of Hannoki (*Alnus* sp.), and this wood selection is obviously different from



Fig. 1. Old wooden mask discovered at Yatsushiro City, Kumamoto, Japan. It was painted with black lacquer and its size is 25.6(L) \times 21.0(T) \times 14.0(H) cm^3 . The mask has been totally deteriorated by insects and especially the right part of the chin has been damaged seriously. Courtesy of Yatsushiro Municipal Museum.

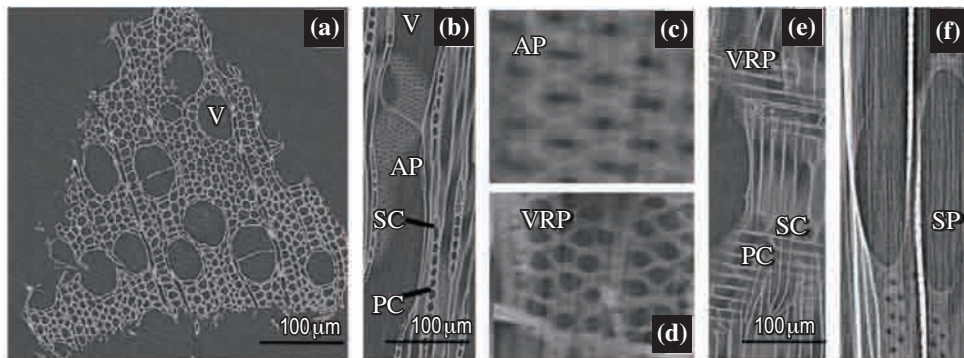


Fig. 2. Pseudo-sections constructed from synchrotron X-ray microtomography dataset of SPring-8: cross section (a), tangential section (b), magnified area of the alternate pitting (c), vessel-ray pitting (d), radial section (e), and simple perforation (f). Note that V: vessel, SC: square cell, SP: simple perforation, PC: procumbent cell, AP: alternate pitting, and VRP: vessel-ray pitting.

the selection for the Japanese wooden masks. The other masks that are not considered as Hahoe masks were also identified as being made of *Alnus* spp. (1969) [3]. There were some concerns that the wooden mask discovered in Kumamoto Prefecture could be one of the Hahoe masks on its basis of the morphological characteristics.

The mask was partly broken and heavily deteriorated by biological attacks. However, in order to understand the history of this mask, the identification of the wood species was requisite. A tiny half-rotted fragment collected during restoration for preservation was used for the analysis. As shown in Figs. 2 and 3, the sample was *Salix* sp., a clearly

diffuse porous hardwood characterized by uniseriate heterogeneous ray and simple perforation, and thus the hypothesis that it is one of the Hahoe masks was ruled out. Since wooden masks preserved in Japan are mostly made of Hinoki (*C. obtusa*), Kusunoki (*C. camphora*), Kiri (*P. tomentosa*), and so on, it is unlikely that this mask was made in Japan. Therefore, it remains likely that this old wooden mask is still the oldest in Korea.

Microcomputed tomography methods hold a tremendous amount of potential. Because of their nondestructive character, the identified samples can be used further for chemical analysis such as component analysis. Recent advances in the stable isotope analysis of wood to trace its geographic site would eventually allow us to determine the origin of such wooden artifacts, i.e., to determine where it came from.

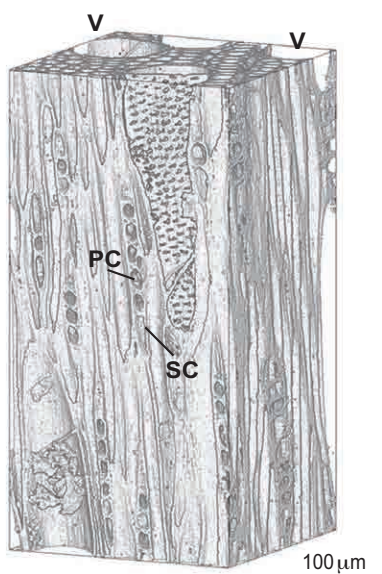


Fig. 3. Typical 3D rendering of *Salix* sp. constructed using synchrotron microtomography dataset. Note that V: vessel, SC: square cell, PC: procumbent cell, and AP: alternate pitting.

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