INTERNATIONAL SYMPOSIUM ON THE CONSERVATION AND RESTORATION OF CULTURAL PROPERTY
– Conservation of *Urushi* Objects –

THE SCIENTIFIC INVESTIGATION OF TWO JAPANESE DANCE MASKS

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Summary

The paper presents the scientific investigation of two Japanese dance masks. Optical microscopy, scanning electron microscopy / energy dispersive X-ray fluorescence (X-ray microanalysis), X-radiography, optical emission spectroscopy, X-ray diffraction and microchemistry were applied to characterize the materials and the techniques used. Conventional C14 techniques yield the age of the wooden support. The C14 dates, the presence of white clay (*hakudo*) and calcium carbonate whites (*gofun*) grounds and stylistic criteria are used to discuss possible dates of origin.

1. Introduction

During the last 15 years hundreds of objects have passed through my laboratory - including some from the Far East. The problems involved were as different as the objects themselves: demands for conservation advice, rare objects where only little was known about the techniques and materials used or objects which turned out to be useful for the application or development of new investigation techniques. Other topics were the history of materials and - last but not least - dating and authenticity testing. The selection of the objects was more or less driven by the art market, by exhibitions to be prepared or by museum colleagues. In short, the situation was far from being systematic.

On the contrary, in the past my work on Chinese lacquerware had a different approach. The evident lack of any technical data seemed to demand a systematic investigation of lacquerware. Ten years after the experimental work is finished and after most of the results have been published[1,2] my view has changed slightly. While remaining a major analytical challenge, the characterisation of *urushi* as a binding medium by pyrolysis mass spectrometry seems to be of minor relevance, whereas my interest focussed more and more on the lacquered object in a whole. It seems to be of current importance for the conservation field to reveal the use of distinct pigments and techniques. This is especially possible because the super-durable material *urushi*[3] preserves most of the pigments in such a way that their history can be studied over a very long period.

In a Western laboratory, however, there are some limitations which make scientific investigations of Oriental art difficult: The main constraint is the lack of related literature written in a Western language. The translation of scientific or art historical Japanese, Chinese or Korean literature is extremely expensive and in most cases not of very good quality. Therefore, the existence of at least an English summary is crucial which, unfortunately, is not provided in most cases. But why not focus on European art and move away from Oriental art? In European museums and private collections there are many important lacquer objects which lack proper preservation, conservation or restoration. Museums, collectors, dealers and conservators ask for scientific support and conservation guidelines are urgently required. This situation has been much the same over the last ten years.

Within the framework of a Japanese - German exchange and research program sponsored by the German Minister of Research and Technology (BMRT) and the Japanese government this presentation aims to examplify an overall examination of two selected lacquer objects as well as to demonstrate how fruitful a close cooperation between art historians and scientists can be.

2. The *Nino Mai* Mask

At the time of investigation (1985) the mask had been in private possession (since 1963/64). The mask is said to come from an Italian

Fig. 1 *Bugaku* mask, *nino mai* type, *hare-men*, for more information see text.

ambassador who had his residence in Japan during the first World War.

The mask (Fig. 1) belongs to the *nino mai* dance which is part of the *bugaku* play. The mask is that of an old woman with swollen face (*hare-men*)[4]. It is life size and its thickness ranges between 15 and 32 mm. The mask is seen to be similar to a piece from the Tamukeyama Shrine, which is now in the Nara National Museum[5].

The condition of the mask is good. Losses could be observed on the left cheek, in smaller areas on the forehead, on the tip of the nose, the tongue, below the chin and along the edges.

The wooden support is made from *Paulownia tomentosa (kiri)*[6]. *Kiri* wood is known to be easy to carve which is done here in a confident way especially around the nose.

The dating of the mask was the major problem. Therefore, upon request by the owner, a 54 mg sample was taken from the wooden support for C14-dating. It was clear from the beginning that the date of the wooden support is not necessarily the date of the mask. However, it was a great surprise, that the C14 age is 2760 ±150 years before 1950 (Hv 14671): The support should therefore be dated 795 - 1130 cal BC!

The macroscopic construction of the mask can be seen in the X-radiography shown in Fig. 2. The layers show a fine crack pattern. The light lines running on the right and left sides of the eyes might indicate a wooden support made of three parts. However, the non-dense structure of the *kiri* wood does not allow a definite decision from the X-radiography how many parts of wood have been used to compose the mask.

A cloth is glued on top of the support[7]. The cloth is intended to stabilise the wooden support and to provide a base for the priming. The X-radiography shows the coarse structure of the cloth which is supposed to be hemp. No sampling and closer investigation was possible. The back of the mask is covered with another coarse cloth which is assumed to be original.

As can be seen from the cross-section (Fig. 3), the thick whitish ground (1) - presumably applied in several layers - is covered with a black layer (2). This black layer shows no inclusions and has a varying thickness.

Its colouration is homogeneous. After application the black layer has been polished. The appearance of (2) allows it to describe it as *nakanuri* layer. The *nakanuri* layer is followed by a fine white layer (3). One or more very thin brownish layers (4) are applied on top. Only layer (3) shows a

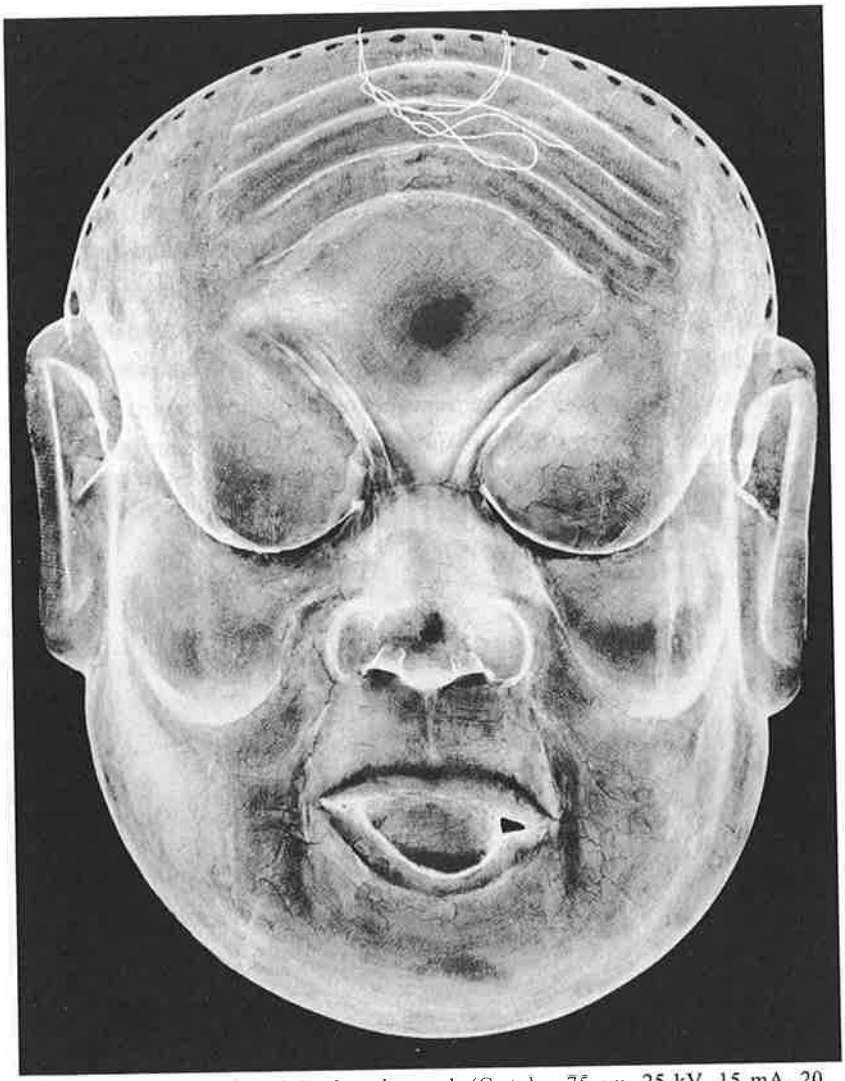

Fig. 2 X-radiography of the *bugaku* mask (Cr tube, 75 cm, 25 kV, 15 mA, 20 sec).

clear orientation for the lath-shaped inclusions: This is best visible in the scanning electron microscope (SEM) image (Fig. 4).

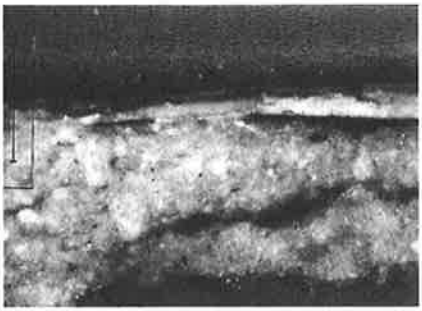

Fig. 3 Cross-section of the *bugaku* mask.

Optical emission spectroscopy (OES) revealed that a sample which included all the layers (1) to (3) is rich in calcium. Additionally, amounts of magnesium, silicon, aluminium and iron, in very low quantities copper, manganese, strontium, sodium, bismuth and titanium are present. The sample's main component has been characterized by X-ray diffraction (XRD, vertical goniometer) as being calcium carbonate ($CaCO_3$, JCPDS 24-27). In 1985, this result led to the conclusion that one or several ground layers of natural calcium carbonate white are present. Following the comments given by Kyotaro Niskikawa, the cross-section shown in

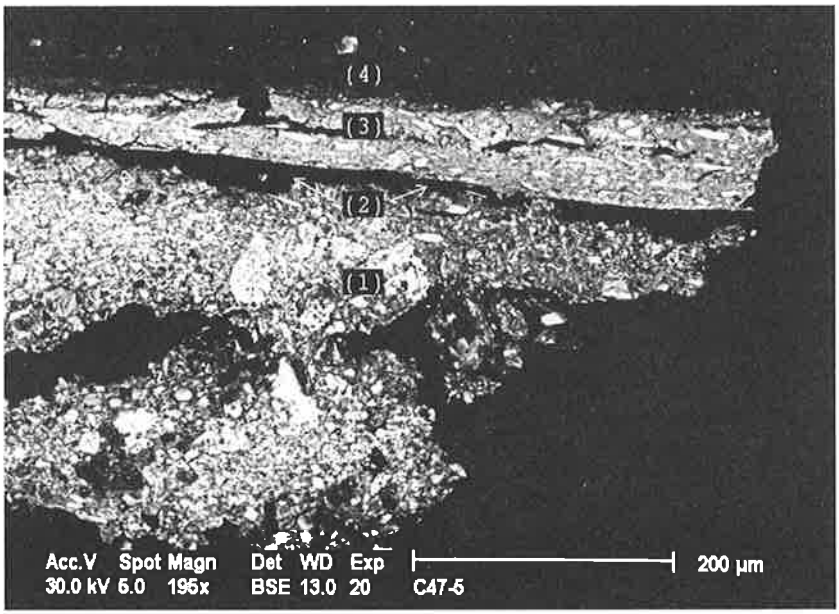

Fig. 4 SEM image (BSE mode) of cross-section Fig. 3, numbers see text.

Fig. 3 has been recently re-examined by X-ray microanalysis: The ground layer (1) contains considerable amounts of silicon, aluminium, calcium, potassium, iron, titanium, manganese and magnesium. Therefore, it could clearly be identified as white clay (*hakudo*)[8]. The *hakudo* ground is supposed to be the original ground of the mask. X-ray microanalysis led to different results for layer (3): Here, calcium is dominant with minor amounts of aluminium, silicon, potassium and iron. From this analytical result, the diffraction pattern (Straumanis) mentioned and the lath-shaped morphology of the particles, it can be concluded, that calcium carbonate in the form of shell white, produced from ground sea shells, has been used (*gofun*[9]). Both different types of ground - *hakudo* and *gofun* - are shown in higher magnification in Fig. 5.

Red paint could only be found on the tongue. The pigment used has been identified as cinnabar by X-ray microanalysis and XRD (HgS, JCPDS 6-256).

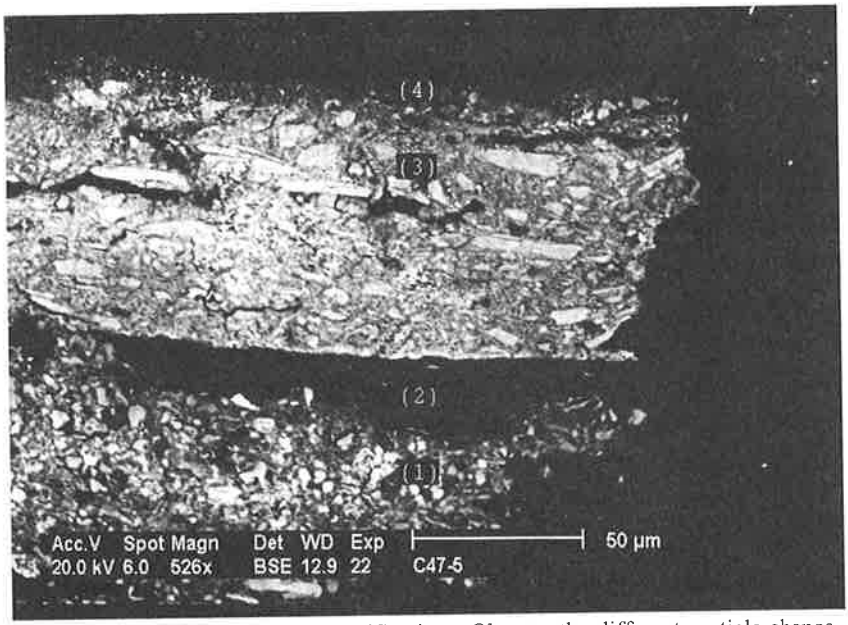

Fig. 5 As Fig. 4 in higher magnification. Observe the different particle shapes in the *hakudo* ground in layer (1) and the *gofun* ground in layer (3).

In one sample which included all the layers (1) to (4), *urushi* has been identified to be part of the binding system by high resolution pyrolysis mass spectrometry[10]: The resulting mass spectra show some of the fragments identified to be specific for *urushi*. Additionally, the high resolution mass spectra show the fingerprint of other compounds. How should these observations be interpreted?

The main advantage of *kiri* is that *kiri* shrinks very little and is lightweight. Therefore it has been used particulary for the production of dance masks, but also for furniture and other lacquer ware. *Kiri* was mainly used in the 8th century, but we have some examples of the later period. In other cases, masks were carved from camphor (*kusu*) up until the 7th century, and from Japanese cypress (*hinoki*) since the Heian period.[11]

The result of the C14 dating was surprising and has been discussed in detail between us and the C14 laboratory. For conventional C14 dating the sample size of 54 mg was rather small. However, as has been stated by the C14 laboratory, this did not influence or falsify the result. Moreover, the possibility that the sample had been contaminated by inorganic ground material or organic materials (such as fossil or skin oils) could be excluded. How else to explain the early date of the wooden support? Some years after the examination, while visiting a mask exhibition in Tokyo, I found a useful statement that "*hinoki* wood of the age of 400 - 500 years is used best"[12] to produce *nō* masks. Obviously, the use of old wood is advisable from the point of view of craftsmanship. So, in our case, the artist may have looked for 'old wood'. Possible sources[13] are fossil wood which can be found on the sea-side. Another and interesting possibility is wood from volcanic areas: The fossil CO_2 absorbed would strongly increase the C14 age. An additional reason to select volcanic wood could be that this material would lend a mystic character to the mask.

The investigation of the media used revealed the presence of *urushi*, however, mixed with other media probably proteinaceous media[14].

Final points of interest are the *hakudo* and *gofun* grounds identified. As can be seen from the cross-section in Figs. 3 and 5, the *hakudo* belongs to the 1st polychromy (including cloth-application, *hakudo* (1) and *nakanuri*

(2)) and the *gofun* to a 2nd later polychromy (*gofun* (3) and brownish top layer (4)). In the literature occurrences of *hakudo* and *gofun* are to some extent controversially discussed. *Hakudo* has been used from the 7th century[15]. *Gofun* - with its much whiter appearance - has replaced *hakudo* around the 15th/16th century[16]. This replacement was a slow process: It started after the *Kamakura* period (after 1332 AD)[17] and seems to have been exclusively used from 1574 onwards (*Momoyama* period)[18]. Not only as a ground material, but also as a white pigment, *gofun* is used on *ukiyo-e* scroll paintings dated from the late 16th to the late 19th century in the very most cases[19]. It should be mentioned, that *gofun* - produced from powdered sea or oyster shells - has been reported specifically for Japan[20]. In respect to our mask, the most important point is that there is strong indication that *gofun* totally replaced *hakudo* in the 15th/16th century.

This presence of *hakudo* in the original polychromy and the strong stylistic evidence to date the piece into the late 12th/early 13th century[21] are in good agreement. An alternative dating into the *bugaku* renaissance during the *Edo* period (1600 - 1867) can be excluded[22]. The *gofun* present in the 2nd polychromy suggests a reworking after the 15th/16th century. This is not unlikely: Whereas polychrome sculpture is not 'used', dance masks are intensively used during the *bugaku* plays and require frequent repair and reworking.

3. The Second Mask

The second mask has been supposed to be a *gigagu* dance mask until the symposium took place. *Gigaku* dances played an important role in ritual temple dances[23]. It is now agreed, that the attribution to the *gigaku* dance is wrong and that the overall quality is far lower than that of the *bugaku* mask described above. For further comments by Kyotaro Nishikawa see at the end of this text.

At the time of the scientific investigation (1990) the mask (Fig. 6) was in the possession of an art dealer. No further information was given

concerning the provenance of the piece except that it was acquired at a small auction house in England.

Sometimes, dance masks cover all the head of the dancer as is the

Fig. 6 The second dance mask, for more information see text.

case for the mask discussed here and its size is therefore life size. Remainings of tufts of hair can be observed. A slightly different mounting proves that the original tufts have been repaired or replaced at least once.

Fig. 7 X-radiography of the second mask (Cr tube, 75 cm, 25 kV, 15 mA, 35 sec).

Those showing greater signs of wear are fixed with wooden tenons in the center of the hair tuft.

The condition of the mask is not as good as that one of the *bugaku* mask. Evidently, flaking parts had been fixed and frequent losses in the black top *urushi* layer had been retouched (some of them with black ink).

Because of the shape described it turned out to be difficult to X-ray the mask (Fig. 7) : The varying thickness of the wooden support led to a partial under-and overexposure of the X-ray film. A visual examination shows that the mask is cut from one piece. Losses mentioned appear black, strong absorbing parts along the furrows - which are associated with a red polychromy - indicate the use of red lead or cinnabar. The eye holes and the holes where the hair tufts have been fixed are clearly visible.

The soft wooden support is discussed as being either *kiri* or *hinoki*[24]. No stabilizing cloth on the front or the back could be detected.

Because the dating of the mask was the key problem, one sample of 490 mg has been taken from the wooden support for C14-dating. The C14 age is 670 ± 155 years before 1950 (Hv 14671). The support should therefore be dated 1215 - 1420 cal AD.

The poor condition of the mask permitted to sample a representative cross-section and several powder samples to determine the ground material and pigments used. Fig. 8 shows the cross-section of a particle sampled below the right eye of the mask.

The very white, thin and dense ground (1) is directly applied on the wooden support (not visible in Fig. 8). It shows good adhesion to the support and is followed by a thick opaque black layer (2) with transparent inclusions. These lath-shaped particles show a preferred orientation along the black layer. The very smooth surface of the black layer suggests the conclusion that it was polished carefully (*nakanuri*). On top of the black layer a red layer (3) and a second thin black layer (4) can be seen. Both, (3) and (4) are of varying thickness. Layers (1) to (4) form the first and original polychromy: The visual impression must have been a light red partly covered with black.

The first polychromy is covered with a second polychromy, which

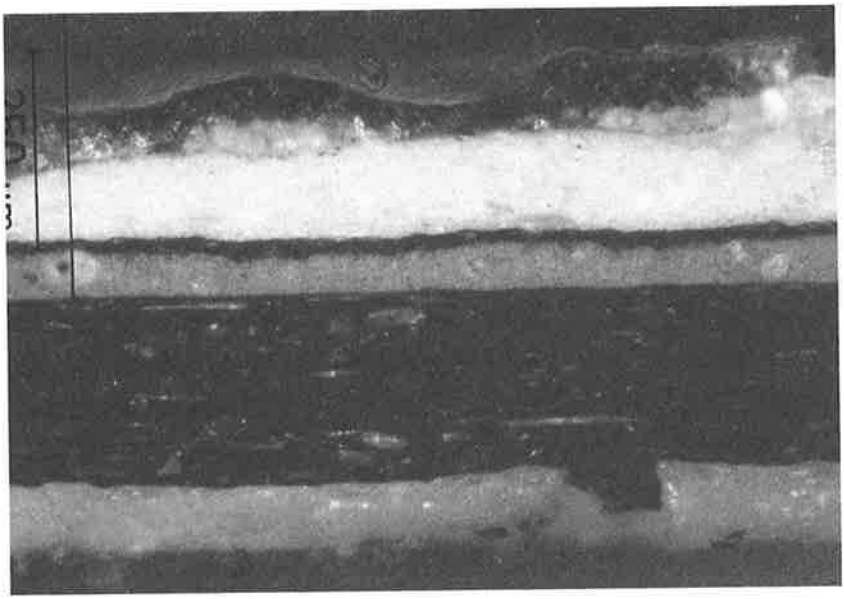

Fig. 8 Cross-section of the second mask

consists of a thick layer of white ground (5), a thin red layer where only a few particles are left (6) and a brownish transparent final layer (7). Within (5) some transparent, lath-shaped particles show again the same orientation as described above. Obviously, this is caused by the application process. The visual impression of the second polychromy was a basic red thinly and translucently covered with brown.

Again, it has been found by OES that the grounds (1) and (5) are rich in calcium. Additional small amounts of magnesium, silicon, aluminium, lead, copper and trace elements such as sodium, strontium, iron, manganese and titanium could be detected. These results could be confirmed by X-ray microanalysis. The main component has been characterized by XRD to be calcium carbonate ($CaCO_3$, JCPDS 24-27). Additionally, quartz (SiO_2, JCPDS 5-490) and traces of possibly gypsum ($CaSO_4.2H_2O$, JCPDS 6-46) have been found.

The characteristic shape of the inclusions, their distribution and orientation can be made best visible on the SEM images (Fig. 9 and 10).

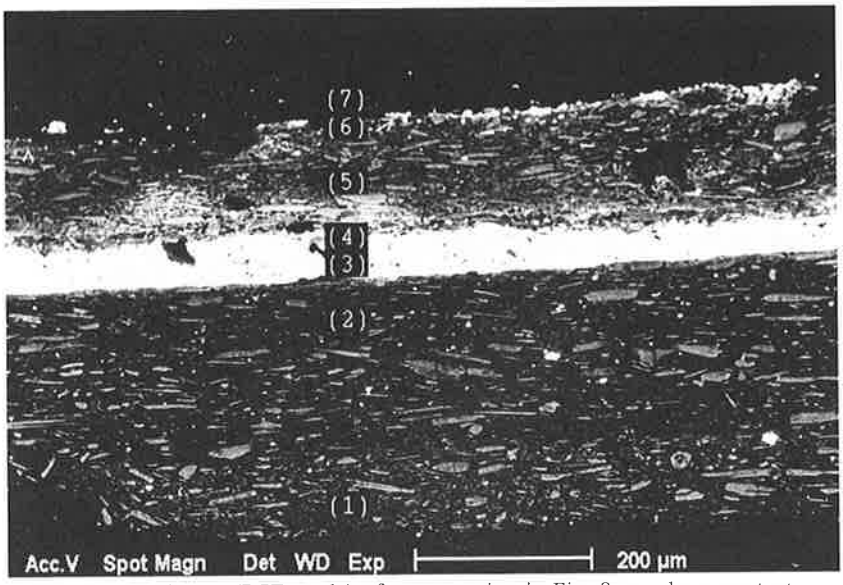

Fig. 9 SEM image (BSE mode) of cross-section in Fig. 8, numbers see text.

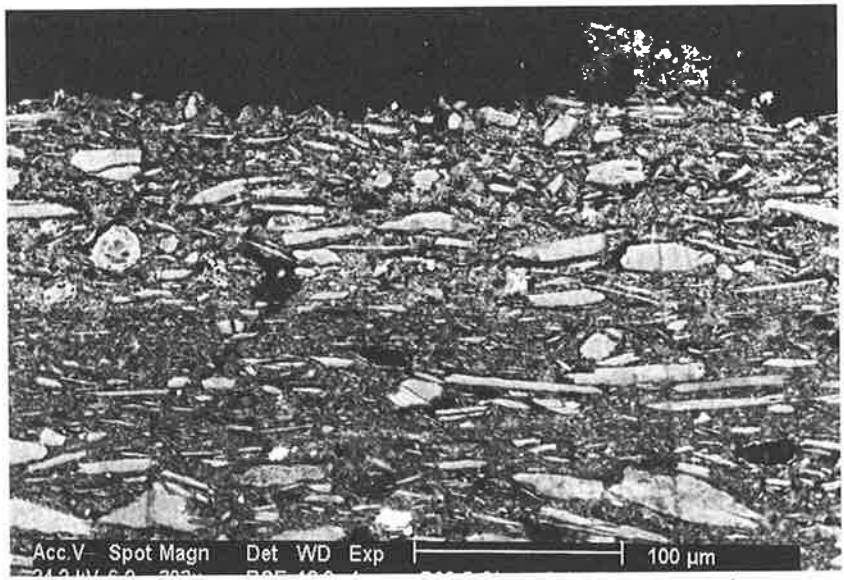

Fig. 10 SEM image (BSE mode) of the upper layers of the cross-section in Fig. 8.

They confirm the presence of *gofun*. A satisfying explanation why *gofun* has been added to the black layer can not be given so far.

The red layer (3) is pigmented with red lead which was confirmed by OES and XRD (Pb_3O_4, JCPDS 8-19). Some single particles of light red cinnabar (HgS) are included which could be identified by X-ray microanalysis showing an increased concentration of mercury and sulphur.

The black layer shows quantities of iron which could be derived from iron (salts) added to darken the *urushi* [25].

As raised by the owner, the presumed date of the (at this time still *gigaku*) mask was 13th/14th century or later. Against the background of the recommendation to use 'wood of the age of 400 - 500 years' (see above) the C14 date of the wooden support is of no use to more precisely date the mask. However, the presence of the original *gofun* ground moved the date to 'after the 15th/16th century'. Therefore, the early date proposed could not be confirmed.

4. Perspectives

On the base of this scientific investigation a conclusive technical description of two masks under investigation can now be given. The results confirm an early date for the *bugaku* mask, but disprove the same for the second mask.

Additionally, the scientific investigation of the two Japanese dance masks raised several questions:

(1) The investigation of the two masks by X-radiography - which yield interesting results for other pieces of lacquerware[26] - did not allow any safe conclusions to be drawn concerning the construction of the wooden core of the mask. Computer tomography would certainly lead to better results. The author would like to encourage other institutions to use the wide range of non-destructive techniques to a greater extent and to publish the results in good reproduction quality.

(2) Was it a general rule to use several hundred years old wood

for the support? The two case studies can be seen as a first step to have a closer look to the date of wooden supports of lacquerware. Further dating experiments should be conducted, however, by more appropriate analytical facilities. Modern C14-dating by using an accelerator requires only a tiny part of the sample used for the two case studies presented.

(3) The identification of *hakudo* and *gofun* grounds allowed to draw solid conclusions concerning the date of the masks. As it could be shown for European pigments[27] and grounds, a mass screening of Japanese grounds would certainly lead to more accurate results. This may require further analytical work and further tiny samples to be taken from third and fourth class, but dated pieces.

(4) A precise determination of mixtures of *urushi* with other media remains an untackled problem. If *urushi* has been used in a pure form, high resolution pyrolysis mass spectrometry yields a fingerprint which shows a set of typical fragments. As shown, this is not valid for mixtures.

5. Postscriptum

As a result of valuable comments given by Kyotaro Nishikawa and of further scientific work, the text of this contribution has been significantly changed shortly after the manuscript for the proceedings of this conference has been finished and just before the presentation in Tokyo in November 1993. Further changes took place after the Tokyo symposium. An additional comment by Kyotaro Nishikawa follows this paper. Finally, it may be mentioned that the *bugaku* mask has been acquired under the directorship of Kyotaro Nishikawa by the Nara National Museum.

KYOTARO NISHIKAWA'S ADDITIONAL COMMENTS

Concerning the presentation and thesis by Dr. Burmester I was asked to comment and it was published in preprint. On two or three points, I would like add to what was presented. First, the underneath of the mask may have been soiled by sweat and oil of the skin of the performers who put it on. Dr.Burmester referred to skin oil. It is not that the dancer would have pasted oil on his face. Rather I talked about the human oil due to metabolism seeped from the skin. Next, concerning *shitaji*, *hakudo* was replaced by *gofun*. Dr. Yamazaki suggests that the period would have been the 15th or 16th century. But Dr. Yamazaki himself says that there is not any sufficient data to meet with that thesis. There is only marginal data to support that hypothesis. I can see the difference of colors of *hakudo* and *gofun* painted by Buddhist sculpture restorers; and from that point of view, I try to discern the differences, and also the changes of the color of *gofun* are inspected. At least until the *Kamakura* period *hakudo* might have been used. That is a sort of inference I can come to, though it may not seem to be a very scientific conclusion. Dr. Burmester said he wanted more data. In fact, in Japan too, concerning to Japanese cultural properties, the database is marginal, and not yet satisfactory by now. So we have to accumulate database of non destructive experimentation which we have just started. Another point I must clear is that, concerning the second mask, it is neither *gigaku* nor *bugaku* mask. With the photographs, it is impossible to judge. Frankly speaking, it seems to be the one of the modern age, not of the 14th century but of a much later period. I would be able to make a more definite judgment when I look at the real object.

References

1 Burmester, A. and Brandt, K., 'Beitrag zur Archäometrie organischer Materialien - Ostasiatischer Lack', Berliner *Beiträge zur Archäometrie* **7** (1982), 216-251.

2 Burmester, A., 'Technical Studies of Chinese Lacquer', *Urushi*, Proceedings of the *Urushi Study Group* (1988), 163-188.

3 J. Kumanotani, 'Japanese Lacquer - A Super Durable Coating (Proposed Structure and Expanded Application)', *Polymer Applications of Renewable-Resource Materials*, ed. Ch.E. Carraher and L.H. Sperling (Plenum 1983), 225-248.

4 Personal communication K. Nishikawa, Tokyo 19.8.1985.

5 Reproduced in K. Nishikawa, 'Bugaku Masks', translated and edited by M. Bethe, Tokyo 1978, No. 57.

6 Examination report D. Grosser, München.

7 According to K. Kitamura, Nara with (possibly *nori*) *urushi*. The use of silk or hemp cloth impregnated with *urushi* and rice flour (*nori urushi*) is described in St. Weintraub, K. Tsujimoto and S.Y. Walters, 'Urushi and Conservation: The Use of Japanese Lacquer in the Restoration of Japanese Art', *Ars Orientalis* (1979), Vol. XI, 39-62.

8 R. J. Gettens, 'Pigments in a Wall Painting from Central China', *Technical Studies in the Field of Fine Arts* VII (1938/39), 99-105. The main component of white clay is kaolinite ($Al_2Si_2O_5$ $(OH)_4$) which has been formed basically of feldspars - responsible for the presence of calcium and potassium - and other aluminous silicate minerals.

9 E. West Fitzhugh, 'A Pigment Census of *Ukiyo-e* Paintings in the Freer Gallery of Art', *Ars Orientalis* XI (1979), 27-38.

10 More information on low resolution pyrolysis mass spectrometry is given in A. Burmester, 'Historical Coating Materials - East Asian Lacquer', *The Proceedings of the 22nd Symposium on Archaeometry* 1982, Editors A. Aspinall und S.E. Warren, Bradford (U.K.), 184-193 and A. Burmester, 'Far Eastern Lacquers - Classification by Pyrolysis Mass Spectrometry', *Archaeometry* **25** (1983), 45-58. The experiments with high resolution mass spectrometry have not been published so-far, but verbally described on various opportunities such as A. BURMESTER, 'Far Eastern Lacquers: No End in Sight', Symposium on Archaeometry 1983, Castel Dell'Ovo, Naples

(Italy), or A. BURMESTER, '2500 Years Chinese Lacquer in a Scientific Point of View', J. Paul Getty Conservation Institute (1984) or A. BURMESTER, 'A Description and Testing of Oriental Lacquer for Museum Purposes', The International Meeting of the *Urushi* Study Group, Tokyo (1985).

11 K. Nishikawa, *op. cit.*

12 'Nô-Masken von Soei Ogura', Exhibition catalogue Düsseldorf, München, Tokyo 1988.

13 Personal communication M.A. Geyh Hannover.

14 Personal communication K. Kitamura, Nara.

15 K. Yamasaki and Y. Emoto, 'Pigments Used on Japanese Paintings from the Protohistoric Period through the 17th Century', *Ars Orientalis Orientalis* (1979), Vol. XI., 1-14, here p. 9.

16 K. Yamasaki and Y. Emoto, *op. cit* p 13.

17 K. Nishikawa, *op. cit.* p 146 and 182.

18 K. Herberts, 'Oriental Lacquer, Art and Technique', London 1962 describes calcium carbonate white as having been "proved to have been produced as early as the Heian period (795 - 1192) ". This statement, however, is lacking any scientific proof so far.

19 E. West Fitzhugh, *op. cit.*

20 R.J. Gettens, E. West Fitzhugh and R.L. Feller, 'Calcium Carbonate Whites', *Studies in Conservation*, 19 (1974), 157-184.

21 by K. Nishikawa, M. Mitsumori and K. Kitamura.

22 "Indeed, in copying older masks, the carver faithfully preserved styles no longer current in sculpture. In the *Edo* period this type of archaism became extremely sophisticated, including conscious antiquing." (K. NISHIKAWA, *op.cit.* p. 29) and "In the *Edo* period, when *Bugaku* was again put under government protection, mask carving was brought back almost to the level of the *Heian* period." (*op.cit.* p. 31).

23 According to K. Nishikawa, *op.cit.* p. 21, *gigaku* dances fell into oblivion after the end of the 17th century. Therefore, not too much is known about the *gigaku* dance flourishing in the *Nara* period (645 - 781). *Gigaku* dances became less important in the *Heian* period (782 - 1184) and disappeared in the *Kamakura* period (1183 - 1332).

24 Unfortunately, a closer investigation turned out to be impossible at that time.

25 Special attention to the agents blackening *urushi* layers is given in Burmester, A., op. cit. ref 2. Further input to this problem is appreciated.

26 B. Milam and H. Gillette, 'X-ray Radiography in the Study of Oriental Lacquerware Substructures', *Urushi, Proceedings of the Urushi Study Group* (1988), 199-226.

27 H. Kühn, 'Terminal Dates for Paintings Derived from Pigment Analysis', *Application of Science in Examination of Work of Art, Proceedings* 1970, Ed. W. J. Young, 199-205.