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Research Article

Manufacturing Technique of the Avalokitesvara Bodhisattva Mural Painting in Geungnakjeon Hall, Daewonsa Temple, Boseong

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ABSTRACT The manufacturing technique was studied through the structure and material characteristics of the walls and the painting layers of the Avalokitesvara Bodhisattva mural of Geungnakjeon Hall, Daewonsa Temple. The mural is painted and connected to the earthen wall and the Junggit, and the wall is composed of wooden laths as a frame, the first and middle layers, the finishing layer, and the painting layer. The first layer, middle layer, and finishing layer constituting the wall were made by mixing weathered soil and sand. It was confirmed that the first layer had a high content of loess below silt, and the finishing layer had a high content of fine-sand and very fine sand. For the painting layer, a ground layer was prepared using soil-based mineral pigments, and lead white, white clay, atacamite, minium, and cinnabar (or vermilion) pigments were used on top of it. The Avalokitesvara Bodhisattva mural was confirmed to belong to a category similar to the soil-made buddhist mural paintings of Joseon Dynasty. However, it shows characteristics such as a high content of fine sand in the finishing layer and overlapping over other colors. Such material and structural characteristics can constitute important information for future mural conservation status diagnoses and conservation treatment plans.

Key Words Buddhist mural paintings, Earth wall, Manufacturing technique, Material characteristics, Conservation

1. INTRODUCTION

Buddhist mural paintings in Korea are mainly painted on the earthen walls that make up wooden architecture. In the mural, a structure called wooden lath was made using branches, and the wall was made based on soil, and then a painted layer was created by mixing natural pigments and coloring agents (Lee, 2013). It is reported that murals, where most of the materials are made of soft materials, have weakness of conservation due to the material characteristics of the mural and environmental factors of the locations of the temple (Lee *et al.*, 2018a). Earlier researches on conservation of buddhist mural paintings in Korea reported that many murals were damaged or difficult to conserve until recently due to the treatments carried out in a situation where there was insufficient research on the materials and manufacturing techniques of murals, therefore research on the characteristics of mural manufacture is necessary. If we accurately identify the materials and techniques used to make murals, reliable research on conservation of murals will be possible based on this, and more systematic and effective conservation measures will be suggested.

A study on the material characteristics and manufacturing techniques of buddhist mural paintings in Korea was conducted in 2006 with the scientific proof of the traditional materials and manufacturing techniques of mural paintings in

Geungnakjeon Hall of Muwisa Temple as the first case (Chae *et al.*, 2006), and in 2008 the manufacturing techniques was studied according to the material characteristics of the mural painting of Bongjeongsa Temple, Andong (Jeong and Han, 2008). Since then, researches that compare the characteristics of buddhist mural materials and manufacturing techniques were conducted, including the researches on the mural painting in Daeungjeon Hall of Heungguksa Temple, Yeosu (Avalokitesvara Bodhisattva), the outside mural painting in Mireukjeon Hall of Geumsansa Temple, Gimje and mural painting in Daeungjeon Hall of Seonunsa Temple, Gochang (Lee, 2016).

Especially in the past, the researches focused on scientific investigations on the national cultural heritage murals or buddhist murals of relatively significant importance, however it is recent trend of research to suggest conservation plans through detailed analysis on the materials and manufacturing techniques of bracket mural in Daeungjeon, Jikjisa Temple (Lee *et al.*, 2018a), bracket mural in Daeungbojeon, Naesosa Temple (Lee *et al.*, 2018b) and bracket mural in Daeungjeon, Gaeamsa Temple (Lee *et al.*, 2022).

The Avalokitesvara Bodhisattva mural and the Buddhist Monk Bodhidharma mural were created on the west and east side walls of Geungnakjeon Hall (Figure 1). The Avalokitesvara Bodhisattva mural measures about 305 × 229.5 cm, which is comparatively belongs to the largest scale than the other murals. The Avalokitesvara Bodhisattva mural and the Bodhidharma mural of Geungnakjeon Hall which are said to have been made around the 18th century, have been designated and managed as treasures in recognition of their value in terms of the art history. Recent investigation on the condition of conservation of the murals confirmed damage to the wall and a damage caused by deterioration of the painting layer, and it was reported that conservation treatment was needed (Haisung Heritage Conservation Institute, 2021). For stable conservation of the murals, the material characteristics and painting technology should be identified first, and based on this, conservation treatment and management of the murals should be carried out through systematic conservation condition diagnosis. Research on the characteristics of mural painting techniques provides important information for diagnosing and interpreting the condition of conservation.

In this study, the structure of the walls and painting layers

Figure 1. Inside mural painting status in Geungnakjeon Hall (A: The Avalokitesvara Bodhisattva mural of west side wall, B: The Buddhist Monk Bodhidharma mural of east side wall).

constituting the Avalokitesvara Bodhisattva mural of Geungnakjeon Hall was identified, and the characteristics of the manufacturing technique were identified by conducting a detailed analysis that includes identifying of the main constituent minerals or detecting of the main components according to the layer.

2. METHODS

2.1. Visual inspection

A digital camera (G15, Canon, Japan) and digital microscope (G-scope, Genie Tech, Korea) were used to investigate the mural structure and manufacturing status. The layers of wall and components were checked focusing on the damaged parts of the outside and inside walls of the Avalokitesvara Bodhisattva mural, and the thickness of each layer of the wall was measured. Also, the manufacturing status was observed focusing on the main colors painted on the earthen wall and the Junggit.

2.2. Microstructures and chemical composition

To identify the characteristics of each layer of samples and the components constituting the material by observing the sample surface and microstructure of the sample exfoliated from the Avalokitesvara Bodhisattva mural. An Stereoscopic microscope (Axio Zoom V16, Carl Zeiss, Germany) was used to observe the sample surface and a high-resolution field emission scanning electron microscope (JSM-7610F, JEOL, Japan) was used to observe the microstructure. Backscattered electron image (BSE) analysis was also performed after coating with platinum (Pt) to obtain sharp and contrasting images of surface conductivity.

2.3. Crystal structure of minerals

An X-ray diffraction analyzer (D2Phaser, Bruker, Germany) was used to analyze the crystal structures of the exfoliated the first and finishing layer samples from the Avalokitesvara Bodhisattva mural. The analysis conditions included the X-ray tube acceleration voltage 30 kv, the current 10 mA, the scanning angle (2θ) 10～90°, the scanning step 0.002°, and the scanning speed 2°/min. Identification of minerals from the X-ray diffraction pattern was performed by comparison with the ICDD card.

2.4. Particle size

Particle size analysis was performed to identify the particle distribution ratio of the soil constituting the wall of Avalokitesvara Bodhisattva mural and to compare the difference in the particle distribution ratio of the samples by layer. Particle size analysis was performed by wet sieving using a stainless standard sieve (JIS Z 8801, Kenis, Japan) with reference to the particle size analysis test of Korean Industrial Standards (KS F 2302). Classification of particle size was expressed as a cumulative percentage by measuring the weight of the remaining sample according to the standards of the US Department of Agriculture and the International Society of Soil Science.

Table 1. List of analysis objects

Sample name	Description		
S1	First layer		Inside the wall
F1	Finishing layer		Inside the wall
P1	Painting layer	White color	Ceremonial cape (white robe)
P2		Green color	A halo behind the head
P3		Orange color	Ceremonial cape (orange robe)
P4		Pale pink color	Lotus pedestal
P5		Yellow color	Mudra
P6		Yellow color	Mudra (painting on Junggit)
W1	Wooden lath		
W2	Junggit		

Table 2. List of analysis object and analysis equipment for mural

Sample name	Classification	Analysis equipment	
S1, F1	Investigation of naked eye	Digital camera	G15, Canon, Japan
	Microscopic analysis	Stereoscopic microscope	Axio Zoom V16, Carl Zeiss, Germany
	Microstructure chemical component	SEM-EDS	JSM-7610F, JEOL, Japan
	Crystal phase	XRD	D2Phaser, Bruker, Germany
	Particle size	PSA	Testing sieve, JIS Z 8801, Japan
G1, P1, P2 P3, P4, P5, P6	Investigation of naked eye	Digital camera	G15, Canon, Japan
	Microscopic analysis	Stereoscopic microscope	Axio Zoom V16, Carl Zeiss, Germany
	Microstructure chemical component	SEM-EDS	JSM-7610F, JEOL, Japan
W1, W2	Species identification of wood	Optical microscopy	ECLIPSE 80i, Nikon, Japan

2.5. Species identification of wood

The specie Identification of wood was performed on wooden lath and Junggit constituting the mural frame. Thin samples were fabricated to a thickness of 20-30 μm from three cross-sections (cross-section, radial cross-section, and tangential cross-section) of the specimen, and then finished with slide glass. Species were identified after observing cell characteristics using a optical microscope (ECLIPSE 80i, Nikon, Japan).

3. RESULT

3.1. Structure of mural

The Avalokitesvara Bodhisattva mural is located between the top Jongryang and the central lintel (Chang-bang) around the center columns of the 2nd row of the west wall of the Geungnakjeon Hall. The mural is painted on the earthen wall connected by three screens, starting with the vertical Junggit in the two left and right rows.

The wall of the mural was made with mud plastered on the wall frame woven with wooden laths, and it seems that it was made with three layers of the first layer, middle layer, and finishing layer, identified through the damaged parts of the inside and outside murals where the Avalokitesvara Bodhisattva is painted. There is a thin middle layer over the first layer in the form of plastering of a mixture of loess and sand. Lastly, there is a finishing layer of a mixture of sand and loess in various sizes and large grains. The wall is about 45 mm thick from wooden laths (horizontal lath) to the finishing layer and the first layer is coarsely plastered onto the frame of wooden laths and mixed with herbaceous plant

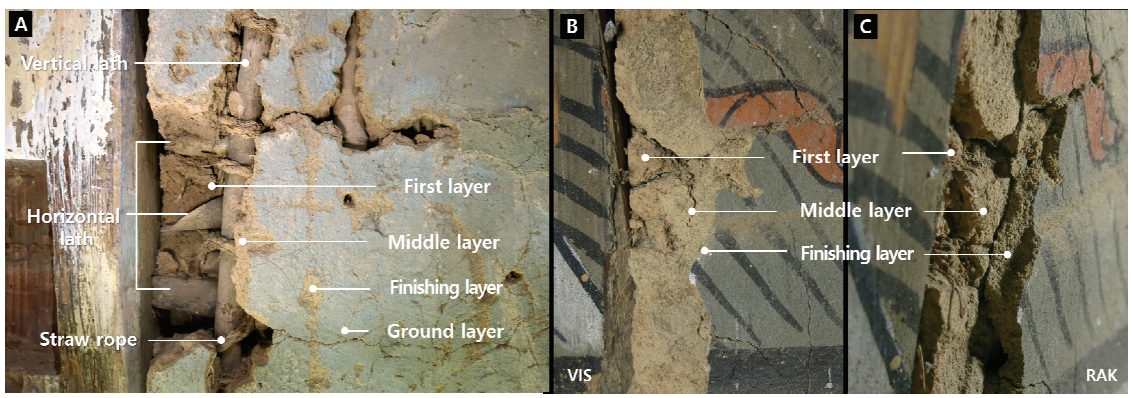

Figure 2. Structure of mural (A: Outside wall of the mural, B and C: Inside wall of the mural).

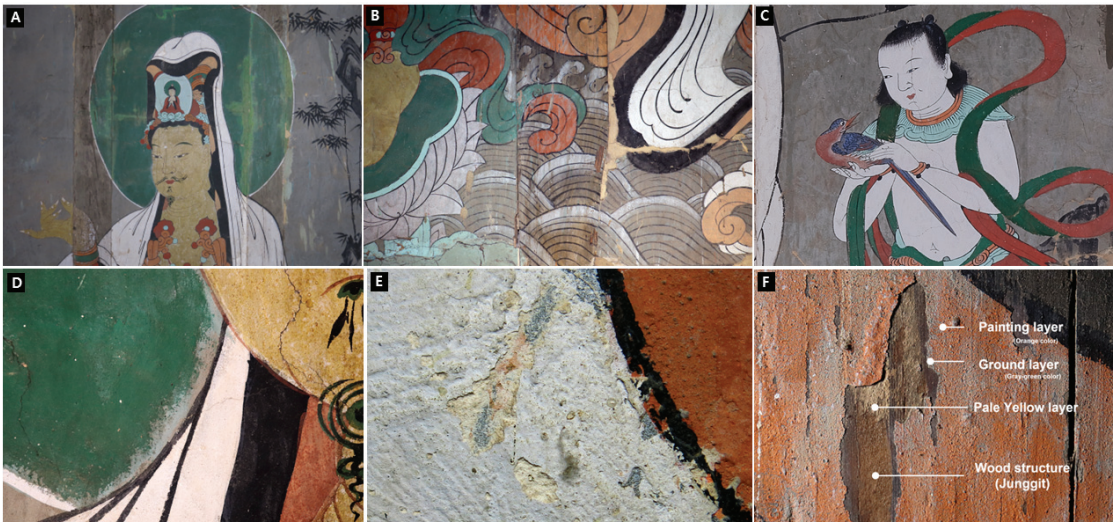

Figure 3. Status of colors painted on the murals (A and B: Part of the Avalokitesvara Bodhisattva, C: Part of Sudhana, D and F: Case of overlapping colors, C: Status of painting on the Junggit).

presumed to be straw. The middle layer is flatly plastered with a thickness of about 10～15 mm on the first layer. On the middle layer, the finishing layer is about 5-7 mm thick and has a high degree of evenness and smoothness (Figure 2).

According to the investigation results on the inner structure of the mural through GPR probe, the shape of wooden laths intersected at a point about 25 mm below to the inside of the wall from the surface of the finishing layer was identified, and it was reported that it was detected to a depth of about 65 mm (Haisung Heritage Conservation

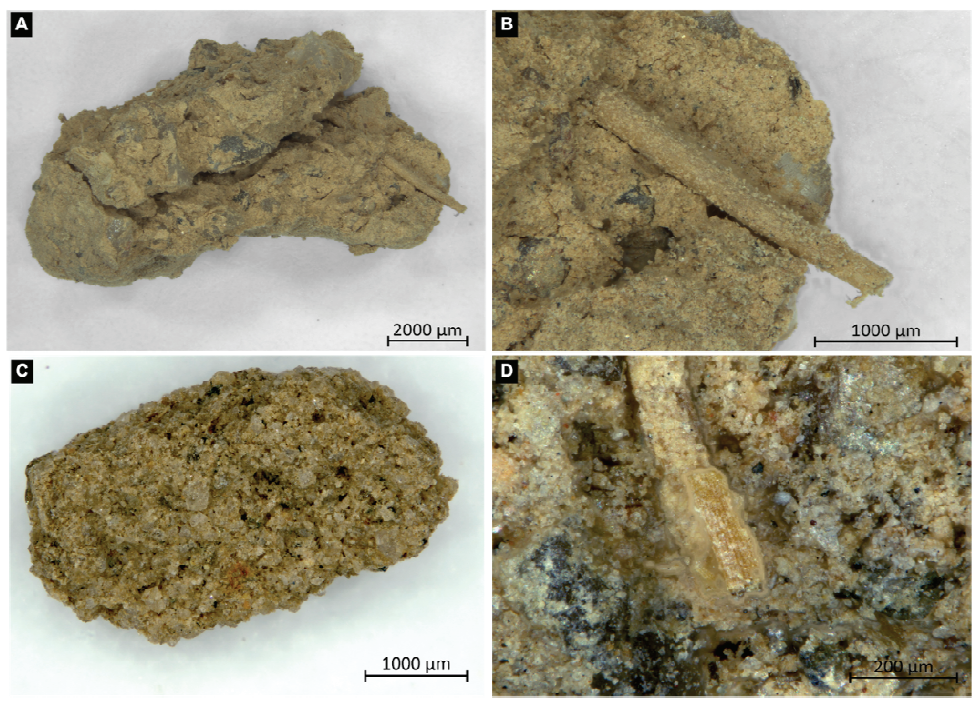

Figure 4. Images of stereoscopic microscope of wall (A: Sample of first layer, B: The stem in first layer, C: Sample of finishing layer, D: Fiber in finishing layer).

Institute, 2021).

It is painted with white, black, green, orange, pink, red, yellow, and blue colors including the gray-green ground layer created on the finishing layer of the mural (Figure 3A, 3B and 3C). In some cases, such as the green of the halo of the buddha and the white of the robes, a pattern of overlapping colors is observed (Figure 3D and 3F). The Junggit is painted with a gray-green color (ground layer) over a pale yellow layer on the wooden surface (Figure 3F).

3.2. Properties of wall

The first layer of the Avalokitesvara Bodhisattva mural is composed of fine soil grains that agglomerate around relatively large grains, and the finishing layer is composed of sand grains in various sizes. In the case of the first layer, the stems of herbaceous plants in the form of short cuts were mixed, and in the finishing layer, a fibrous-presumed material with a thin thickness was identified (Figure 4).

Figure 5, Table 3 show the distribution ratio of the particles composing the first layer and the finishing layer. Regarding distributions of the sizes of the mineral particles used in the first layer, 23.29% was for the very-coarse sand, about 5.22% for the coarse sand, about 4.42% for the medium sand, about 6.83% for the fine sand, about 11.65% for the very fine sand, and about 48.59% for the below silt. The sizes of the mineral particles used in the finishing layer were 3.43% for the very coarse sand, about 10.78% for the coarse sand, about 13.24% for the medium sand, about 45.59% for the fine sand, about 14.71% of the very fine sand, and about 12.25% for the below silt. In the first layer, grains of the below silt and the very coarse sand were confirmed as the main particle sizes, so it seems that large and coarse grains were mixed with grains the below silt. The finishing layer has relatively high content of fine sands and very fine sands compared to the sands of other sizes, so it seems that it is mainly made of sand of fine grain size.

As a result of X-ray diffraction analysis to identify the minerals constituting the wall, the main diffraction peaks appearing in the diffraction pattern of the first layer were confirmed to be quartz, microcline, and cristobalite, a kind of silicate mineral. In case of the finishing layer, quartz and orthoclase were detected as the main constituent minerals (Figure 6). Minerals constituting the first layer and the finishing layer were mainly identified as feldspars such as quartz. It can be understood that the wall of Avalokitesvara Bodhisattva mural was mainly made of weathered soil and sand originating from rocks.

Table 3. Results of particle size analysis

(unit: %)

	Very coarse sand		Coarse sand	Medium sand	Fine sand	Very fine sand		Below silt	
	Over 1.0 mm	1.0-0.5 mm	500-300 μm	300-212 μm	212-100 μm	100-75 μm	75-45 μm	45-25 μm	below 25 μm
S1	13.25	10.04	5.22	4.42	6.83	4.82	6.83	20.08	28.51
F1	0.00	3.43	10.78	13.24	45.59	5.88	8.82	6.86	5.39

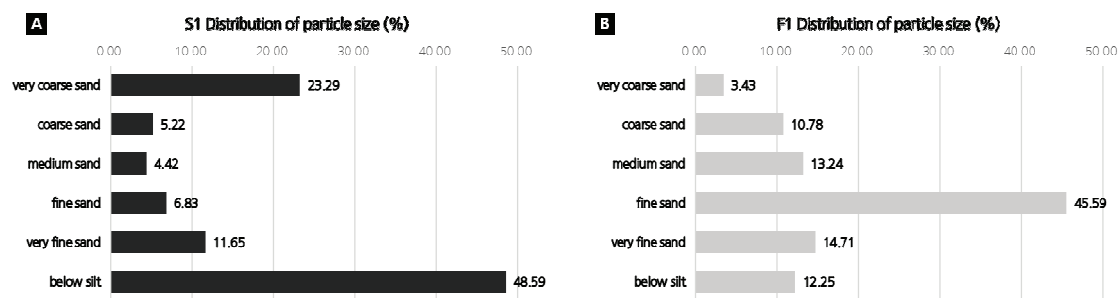

Figure 5. Distribution ratio of the particles size (A: First layer, B: Finishing layer).

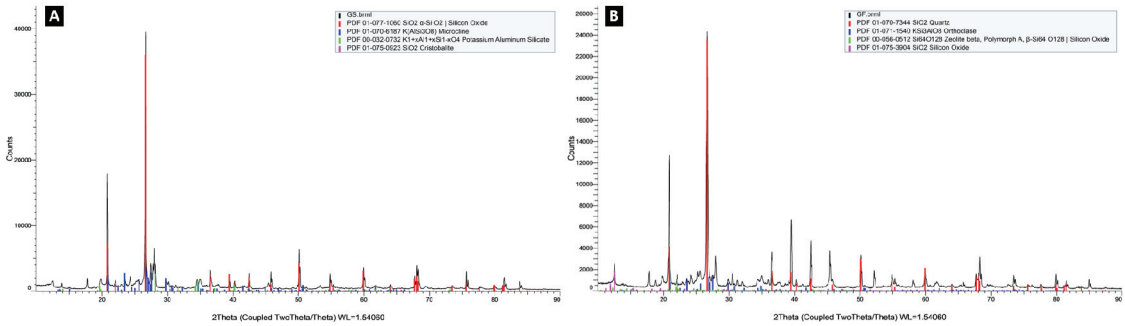

Figure 6. Result of X-ray diffraction analysis (A: First layer, B: Finishing layer).

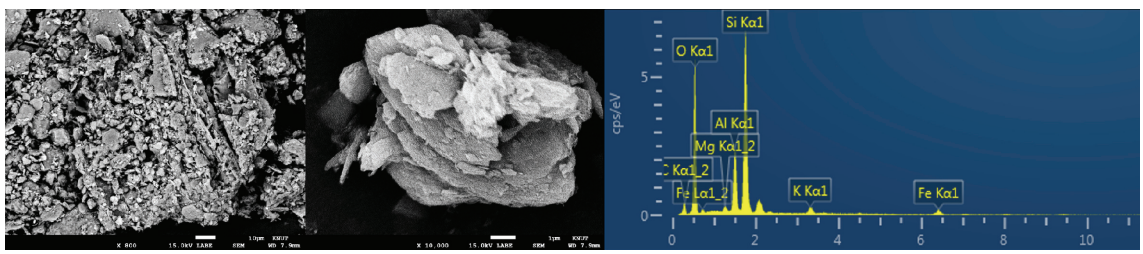

Figure 7. Result of microstructures and chemical composition analysis of first layer.

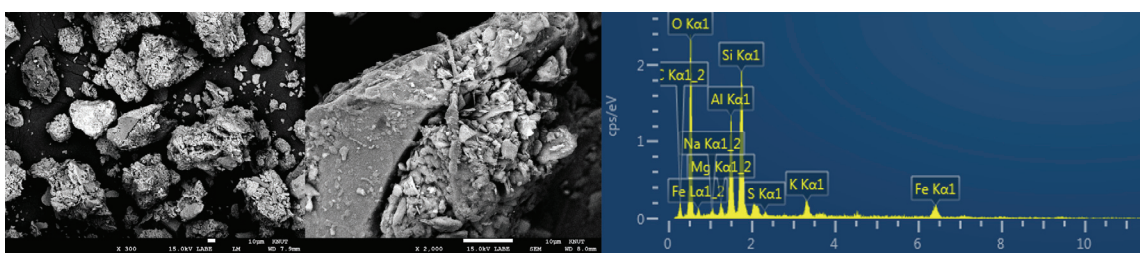

Figure 8. Result of microstructures and chemical composition analysis of finishing layer.

As a result of microstructure observation and chemical composition analysis of the samples, a structure in which small soil grains in the shape of polygons and plates were aggregated was identified in the first layer, and traces presumed to be indentations of herbaceous plants were also observed (Figure 7). The elements detected in the first layer were silicon (Si), alumina (Al), iron (Fe), potassium (K), magnesium (Mg), etc., which are the elements mainly detected in the soil. In the finishing layer, soil grains, which appear to be silt or clay minerals, formed an aggregate on the surface of relatively large grains compared to those seen in the first layer, and the material presumed to be fibrous was identified. The main elements detected in the finishing layer include silicon (Si), alumina (Al), iron (Fe) and potassium (K), which are the elements found in the soil, similarly as found in the first layer (Figure 8).

3.3. Properties of painting layer

It was confirmed that the Avalokitesvara Bodhisattva mural was painted after being painted over the finishing layer made soil. As a result of cross-sectional examination of the painted samples, it was found that the ground layer of the mural was observed as a mixture of green and white particles, and had a thickness of minimum of 52.03 μm and the maximum of 342.4 μm. As a result of analysis on the chemical composition of the layer, Silicon (Si) and Alumina (Al) were the main components, and Iron (Fe), Potassium (K), Calcium (Ca), etc. were detected. The ground layer

seems to have been painted using soil-based pigments such as green earth or white clay.

The painting layer of P1 (white color) is confirmed to have a thickness of minimum of 266.5 μm and maximum of 407.1 μm over the ground layer (Figure 9). As a result of the chemical composition analysis, lead (Pb) was detected in the upper part and Silicon (Si) and Alumina (Al) were found to be the main components in the lower part, indicating that two layers exist. The P1 was painted using white clay after the ground layer, and it seems that lead white with a thickness of minimum of 43.29 μm and maximum of 62.95 μm was overlapped on it.

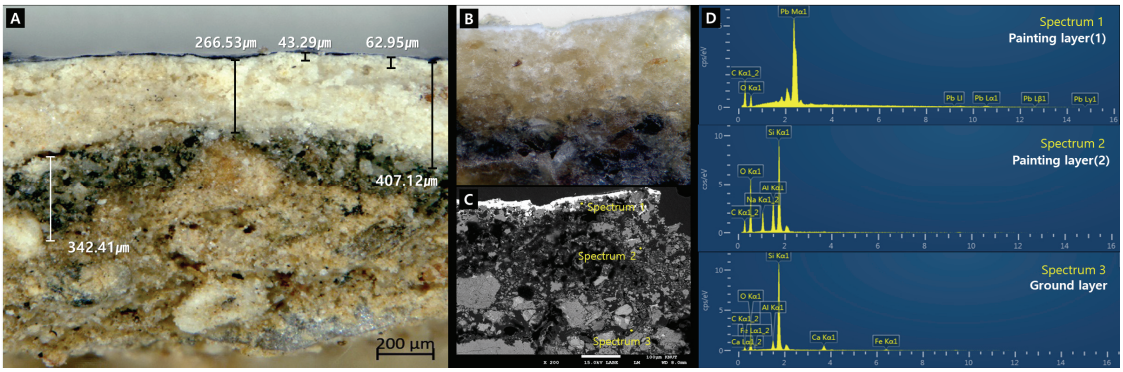

Figure 9. Cross section of P1 sample (A, B: Optical microphotograph, C: FESEM-BSE microphotograph, D: EDS spectra).

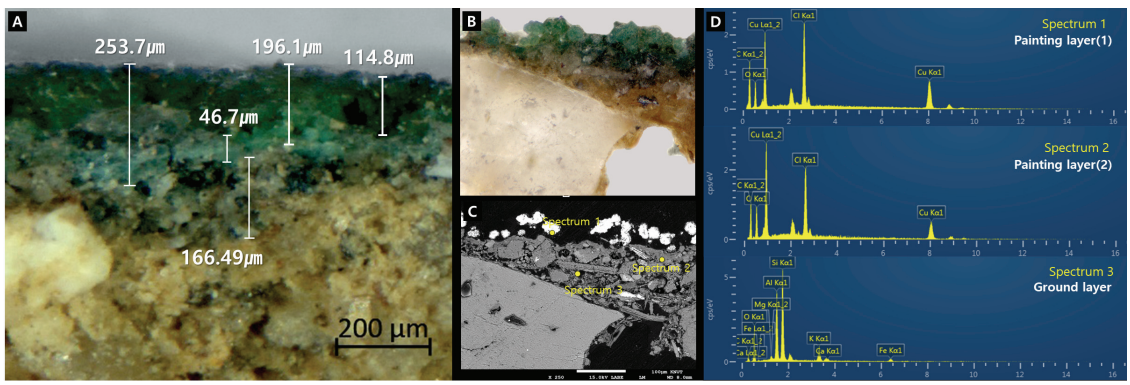

Figure 10. Cross section of P2 sample (A, B: Optical microphotograph, C: FESEM-BSE microphotograph, D: EDS spectra).

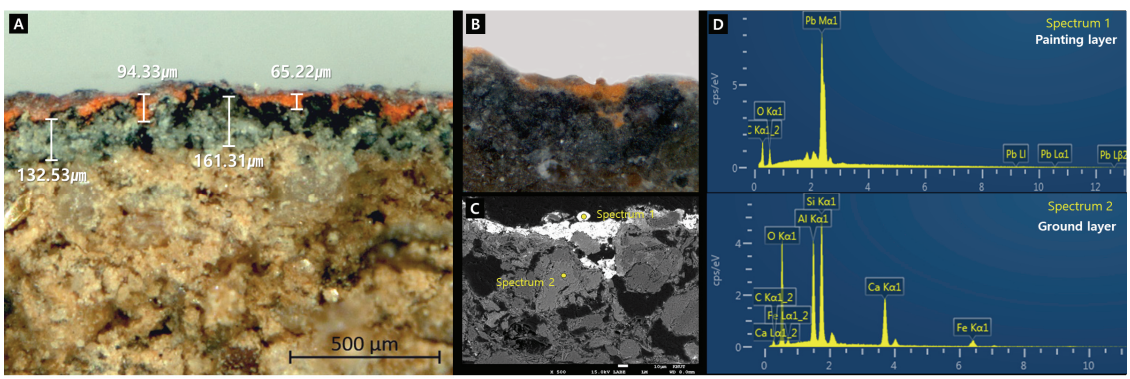

Figure 11. Cross section of P3 sample (A, B: Optical microphotograph, C: FESEM-BSE microphotograph, D: EDS spectra).

The painting layer of P2 (green color) was confirmed that the thickness is minimum of 196.1 μm and maximum of 253.7 μm over the ground layer. The painting layer is found to have two layers, and dark turquoise color (Hayeob) is confirmed over the greenish blue color. In both layers, copper (Cu) and chlorine (Cl) were detected as the main elements (Figure 10), and it seems that they were painted using a copper chloride-based pigment.

As for the painting layer of P3 (orange color) with a thickness of minimum of 65.2 μm and maximum of 94.3 μm is identified over the ground layer. In part of the painting layer, a thin layer of black applied under the orange painting layer is observed (Figure 11). As a result of analysis of the chemical composition of the orange painting layer, lead (Pb) is the main component, therefore it seems that minium was used.

The painting layer of P4 (pale pink color) is confirmed to have a thickness of minimum of 25.08 μm and maximum of 30.99 μm over the ground layer (Figure 12). The painting layer is observed as a pale pink color with a mixture of white and red particles. In the painting layer of P4, Lead (Pb) was detected as the main element, and some Mercury (Hg) and Sulfur (S) were also identified (Figure 12). It is estimated that the painting layer was painted using lead white and mercury sulfide pigments.

Lastly, the thickness of P5 and P6 painting layers (yellow color) was minimum of 26.2 μm and maximum of 81.8 μm, and both a layer of white color and a layer of transparent yellow were confirmed over the ground layer (Figure 13, 14). In the painting layers of both samples, lead (Pb) was detected as the main component, therefore it seems that lead white was used, and the element contributing to the color development of yellow was not identified, so it is presumed that organic pigments were used. Phosphorus (P) and chlorine (CI) were detected at the top of the two samples (Figure 13, 14), which seems to be related to the white stain found on the surface of the painting layer. In addition, Iron (Fe), Silicon (Si), Alumina (Al), Potassium (K), etc. were mainly detected in the pale yellow layer under the ground layer of P6 sample, which is presumed to be a soil-based material (Figure 14).

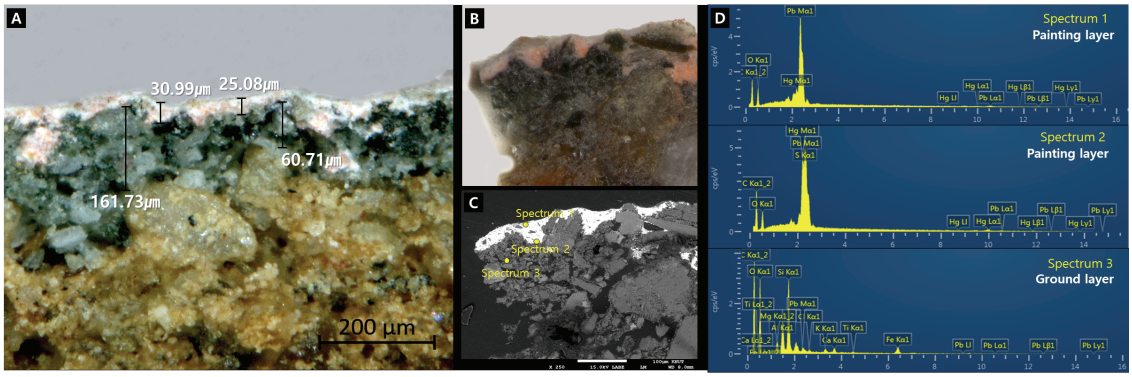

Figure 12. Cross section of P4 sample (A, B: Optical microphotograph, C: FESEM-BSE microphotograph, D: EDS spectra).

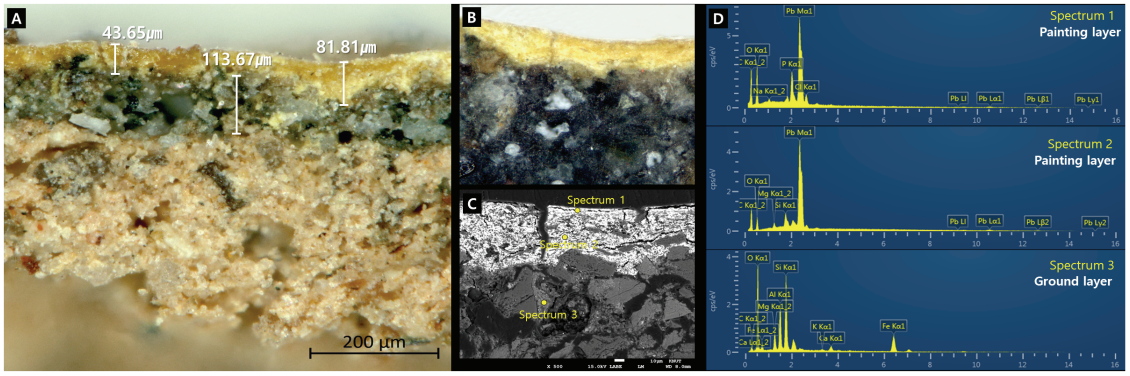

Figure 13. Cross section of P5 sample (A, B: Optical microphotograph, C: FESEM-BSE microphotograph, D: EDS spectra).

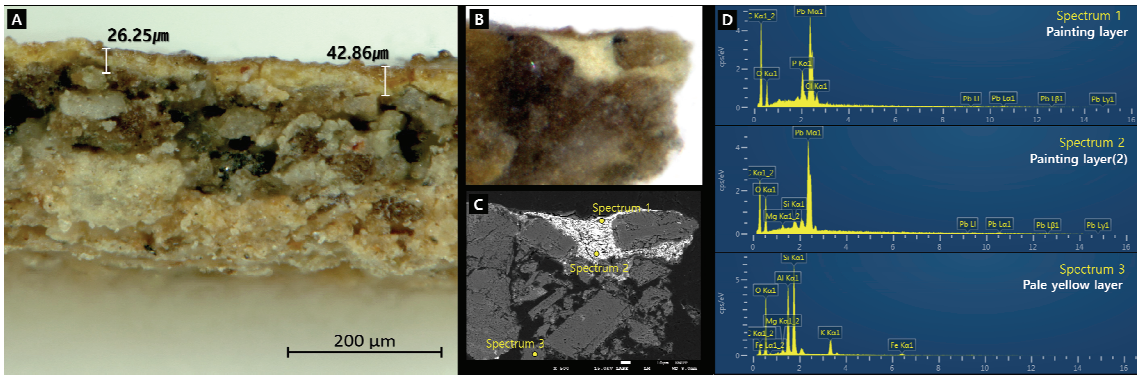

Figure 14. Cross section of P6 sample (A, B: Optical microphotograph, C: FESEM-BSE microphotograph, D: EDS spectra).

Table 4. The main chemical composition of the painting layer sample

Sample name	Description	Major elements
P1	White color	Pb, Fe, Si, Al
P2	Green color	Cu, Cl
P3	Orange clolor	Pb
P4	Pale pink color	Pb, Hg, S
P5	Yellow color	Pb, P, Cl
P6	Yellow color	Pb, P, Cl

Painting layer

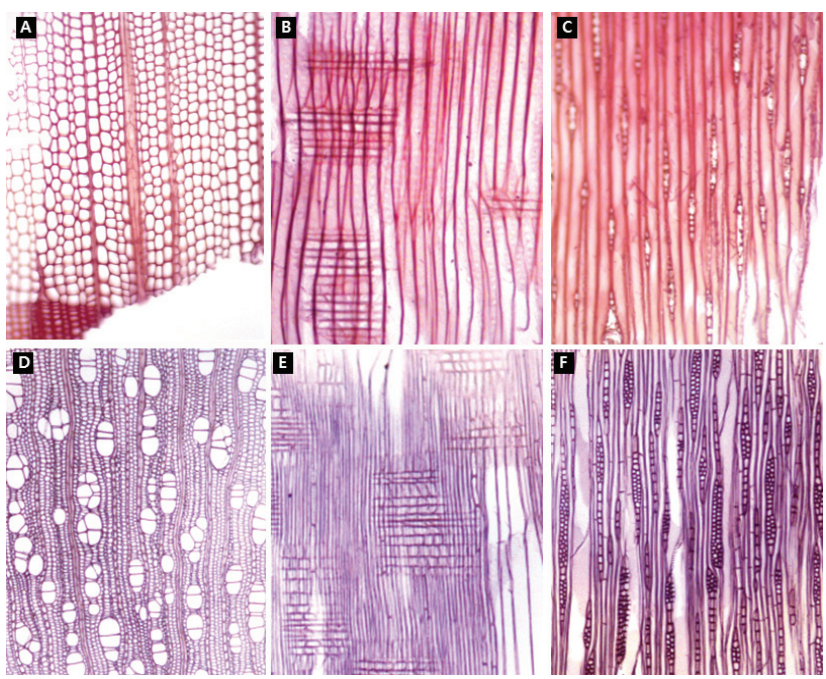

Figure 15. Micrographs of identification of wooden structure result (A: Cross section of pine group, B: Radial section of pine group, C: Tangential section of pine group, D: Cross section of birch group E: Radial section of birch group, F: Tangential section of birch group).

3.4. Identification of wooden structure

The Junggit on which the Avalokitesvara Bodhisattva mural was painted was identified as a pine tree. Pine trees are conifers, with clear boundaries of annual rings and spring and autumn trees, and the material is uniform, and vertical tree regions are found in the cross section. In the radial section, one row of bordered pits can be found, and window-like pits were found in the field pits where the tracheid and the ray parenchyma cell intersect at right angles. In the wall of radial tracheids, dentate thickening, an important characteristic that distinguishes pines and cypresses, was identified. In the tangential section, the adiabatic radiation structure and the spindle-shaped radiation structure including the horizontal resin canal can be seen. In the genus Pineaceae, it is divided into pines and cypresses depending on the presence or absence of dentate thickening in the radial section. Traces of dentate thickening were observed, and it was identified as *Pinus spp* (Figure 15A~C).

Wooden laths in the wall of the Avalokitesvara Bodhisattva mural were confirmed that it was made by using various kinds of hardwoods and bamboo. As a result of tree species analysis through exfoliated wood, it was identified as Birch (*Betula*). Birch is a diffuse-porous wood with a smooth transition of the size of the conduit within the annual ring, and the shape of the conduit is circle or oval and composed of solitary pores or 2-3 radial multiple pores. The conduit has scalariform perforations, and the inter-conduit pits have small alternate pitting. The medullary ray was multiseriate ray of single row or 2-3 rows, and it was identified as a birch genus as it was confirmed to be heteromorphic (Figure 15D~F). The genus of birch includes Dwarf small-leaf birch (*B. chinensis*), black birch (*B. davurica*), Korean birch (*B. costata*), and Erman's birch (*B. ermani*).

4. DISCUSSION

By conducting scientific analysis on the structure and material of the Avalokitesvara Bodhisattva mural of Geungnakjeon Hall, Daewonsa Temple, it was possible to identify the material characteristics and manufacturing technique of the mural.

It was confirmed that the mural was painted on an earthen wall consisting of vertical Junggits of 2 rows in the left and right and 3 parts, and the wall is composed of a frame woven into wooden laths with straw ropes, the earthen wall was made by 3-step plastering of <first layer>-<middle layer>-<finishing layer> in that order.

The layers composing the wall can be confirmed through the difference in the composition of materials and the condition of plastering according to the functional role. The first layer is roughly plastered with soil mixed with loess, gravel, and coarse sand around wooden lath, and the finishing layer is plastered flat using fine sand to prevent cracks. Also the condition of highly smooth plastering was found in the lower layer where the finishing layer was peeled off, indicating that the middle layer was produced.

In the wall of the Avalokitesvara Bodhisattva mural, chemical components found in general soil materials such as Silicon (Si) and Alumina (Al) were detected, and crystalline aggregates having a plate-like structure and minerals of the feldspar type were identified, therefore it can be said that sedentary deposit and sand from rocks were used as the main materials.

And considering the fact that the soil constituting the first layer has high content of loess smaller than silt, is mixed with coarse sand, and added with fibers such as chopped straw, the first layer seems to be made under the conditions that can improve the strength and durability of the wall. In the finishing layer, it was confirmed that the content of fine sand and very fine sand was high. It seems that the physical properties are improved by using fine sand, but it was made under the conditions in which very fine sand were mixed relatively more than silt in order to prevent shrinkage and cracking due to intergranular stress.

The structure of the Avalokitesvara Bodhisattva mural can be said to be the same as that of Korean buddhist mural paintings studied so far, and the materials used to make the murals are also considered to be similar. However, differences can be found in the combinations of the materials and manufacturing techniques. For example, the support layer of a mural is mud and wood (Junggit), and there is a ground layer on it, and there is a paint layer painted with overlapping colors. It is also characterized by a high content of fine sand in the finishing layer. These are closely related to conservation of buddhist murals. The earthen walls of traditional wooden architecture in Korea are composed of three layers, and each layer maintains a complementary

relationship with each other. Though the rate of contraction and expansion due to humidity or temperature is different, so the cohesion between the layers is lost and separation occurs, and such damage appears in most of the walls (Han, 2019). Such damage is not noticeable in the Avalokitesvara Bodhisattva mural of Geungnakjeon Hall, Daewonsa Temple, and it seems to be the result of the difference in the content ratio of fine sand compared to that of other buddhist murals studied in the past.

As for the color of the mural, information on five types of painting layers, including white, green, orange, pale pink, yellow and gray-green, which is the ground layer, was identified. The component mainly detected in the soil was identified for the ground layer, and this component may be a soil-based pigment, and green earth or white clay appears to be used through the grains constituting the layer. Buddhist murals of Joseon Dynasty were usually painted after preparing a stable and fine ground layer using yellow ocher or green earth (Noerok) over the finishing layer (Lee *et al*., 2015).

The white painting layer of the Avalokitesvara Bodhisattva mural was made by overlapping white clay and lead white, and it seems that the green painting layer used atacamite, a copper chloride pigment. The orange painting layer seems to be colored with minium, and the pale pink is presumed to be made by mixing lead white and cinnabar (or vermilion). Lastly, it seems that the yellow painting layer was colored using organic pigments after painting lead white. The existence of the ground layer constituting the painting layer and the pigments used for coloring are considered to be similar to the categories of the pigments and painting styles used in the buddhist murals of Joseon Dynasty studied so far.

The painting layer of the Junggit was confirmed to be painted thinly on the wood, over pale yellow layer, including the ground layer of gray-green color. Iron (Fe), Silicon (Si), and Alumina (Al) are identified as the main elements in the pale yellow layer, so it is presumed to be a soil-based material. The painting method of the part is similar to the order of the priming layer, the gachil (ground layer), and the painting confirmed in the so-called dancheong technique, and it is necessary to clarify the painting technique through further in-depth analysis.

5. CONCLUSIONS

The Avalokitesvara Bodhisattva mural of Geungnakjeon Hall, Daewonsa Temple is made of wooden laths as the frame, mixed with loess, sand, and herbaceous plants to create the first layer, and on top of which the middle layer and finishing layer were made by mixing loess dough of high sand content and fibers. The painting layer seems to be painted by preparing a smooth mural surface with green earth etc., and then painting lead white, white clay, atacamite, minium, and cinnabar (or vermilion) pigments 1-2 times to create the icon. Especially through detailed analysis on the painting layers of the cross section of the samples, the functional role of the ground layer widely used for buddhist mural paintings could be confirmed.

The structure and materials of the Avalokitesvara Bodhisattva mural of Geungnakjeon Hall, Daewonsa Temple show similarity in the painting style in terms of the earthen wall, painted pigments, and manufacturing techniques, compared to those of the buddhist murals of Joseon Dynasty studied so far. Such information can provide useful data for diagnosing the conservation status of murals, and is expected to provide effective information on materials and technologies for establishing conservation plans in the future.

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