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# Basic Survey Study for Preservation of Damaged Tile Sculpture Artwork

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**ABSTRACT** This is a basic study on the artwork of the artist Ji Yeong Kim, “Ascending up the river against the current ...” currently being exhibited in the sculpture park of Suwon World Cup Stadium and it was confirmed that tiles used in the artwork production are classified into 2 types, namely, porcelain tile and ceramic tile, through scientific analytic method. It was confirmed that the tiles that form the overall background of the artwork are unglazed porcelain tiles with the same exterior and interior physical state that experienced absorption rate of 0.4% and firing at high temperature of more than 1,300℃. It was possible to discern that tiles used for the portion presumed to have embodied fish tail are 3 types with the different exterior and interior physical state from each other that have experienced absorption rate of more than 10% and firing at temperatures in the range of 1,000～1,200℃, and that they were manufactured by being coated with glaze in which pyrophylite or dolomite range mineral has been mixed. As the result, it was possible to discern that porcelain tiles were used as the material for outdoor tile sculpture artwork due to its advantages including stability such as durability and water-resistance, etc. while ceramic tiles were used due to their ability to realized diversified colors and patterns through scientific analysis.

**Key Words** Tile sculpture artwork, Outdoor piece artwork, Porcelain tile, Ceramic tile, Mosaic tile artwork, Tile artwork preservation

## 1. INTRODUCTION

The term tile is derived from the Latin word ‘Teagula’ meaning covering up and signifies thin and small ceramic plate with gloss on the surface or those manufactured by firing clay as the raw material for use as decoration by attaching to wall or floor, etc. It was possible to confirm the origin of tile through the cases of discovery of tile beginning with tiles with blue colored overglaze estimated to be produced at about 3,000 BC found in 3 locations in the Saqqara of Egyptian pyramid and excavation of tiles with observation of trace of the use of glaze in the remains of Abydos Temple estimated to be produced at about 1500 BC (Jung, 2000).

Tiles began to be used in full scale due to the influence of Islam that began to be propagate at around 610 AD with mass production of tiles beginning at the time of the industrial revolution in the 19$^{th}$ century after having undergone various stages including colored potteries of Italy during the era of Renaissance, imaginary picture tiles of England and Netherlands, and ceramic tiles of Germany, etc. Since then, the development of terracotta type plate imparted influence on modern architectural ceramics, which was then led to the advancement of environmental art, ceramic wall mural, and ceramic and tile arts (Park, 2016).

In the case of Korea, it is estimated the bricks were used for the first time during the era of the Three States beginning with their uses in the tombs in Goguryo and Baekje before advancing to their uses in decoration of building exterior and floor, etc (Ko and Ko, 1992). It is estimated that the tiles with the formats used nowadays were first introduced to Korea at about a century ago and, as a case for confirmation of the use of such tile by means of written record, it was disclosed through restoration works that tile manufactured by Minton Hollins of England was used at the time of construction of a large greenhouse in Changgyeonggung Palace as the first western style greenhouse in Korea (Cultural Heritage Administration, 2017).

In addition, majority of tiles used in Korea during this era were supplied through Japan and tiles began to be manufactured in Korea as a single product when Goryeo Special Ceramics began to manufacture tiles at its factory in 1955. Since then, the tile industry began to be developed and advanced in full scale with the commencement of introduction of the latest facilities necessary in tile production including spray dryer, kiln and press, etc. along with rapid increase in the residential construction in the middle of 1970's.

The body for ceramic tiles that have been manufactured after having equipped mass production system in Korea was composed by using natural raw mineral materials and has been used widely as internal and external finishing material due to its outstanding durability, water resistance, chemical resistance and fire resistance, etc. (Lee, 2014). These tiles are classified into porcelain tile, ceramic tile and stoneware tile in accordance with their absorption characteristic and are subdivided into interior tile, exterior tile and floor tile, etc. in accordance with their uses (Park, 2012).

Although it was difficult to find data on studies conducted intensively on the history of the use of tiles, which have been used as interior and exterior finishing material in buildings, as material for artworks, it is deemed that the characteristic that artistic value can be manifested on the tile, for which the excellence as a construction material based on its durability, water resistance and hygiene, etc. has been proven, demonstrated its value as an artwork material. In addition, since it is possible to endow pictorial, sculptural and aesthetic functions to tile in accordance with the intention of the artist and directionality of the artwork, achieve economic value through mass production and differentiation in patterns and color designs, it has been used as an artwork material until today.

Although tile sculpture artwork includes small tile craft, majority are the artworks that are exhibited in the exposed outdoor environment including buildings, public art, environmental sculptures and large-scale sculptures that utilize mosaic or art-tile method. Tile sculpture artwork is produced in the format of pasting tiles on walls, creation, pillar, tunnel and sculpture made of concrete, brick and/or metal, etc. by using synthetic resin adhesives in accordance with the intents of the artwork and artist. Given the characteristics of tile sculpture artwork exposed to the atmosphere, phenomenon of damages to such artworks are occurring due to discoloration and bleaching of tile due to diversified external environmental damaging factors including atmospheric pollutants, changes in temperature and humidity, acid rain and UV ray, etc., exfoliation of tile due to degradation in the adhesion strength arising from deterioration of adhesive, weathering phenomenon due to external impact, rain and wind, loss and erosion of detached and exfoliated tile, erosion and weathering of the creation being exposed to external environment due to exfoliated tile and biological damages (Figure 1).

However, there in fact are insufficient studies on investigation of the causes and types of damages, and restoration of the original state through analysis of the

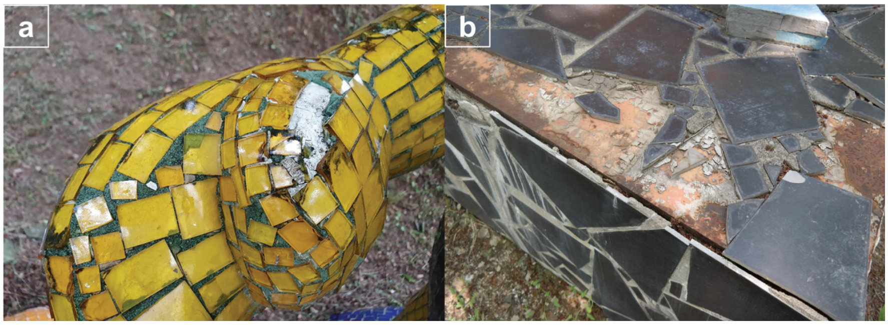


**Figure 1.** Damages to tile sculpture artwork. (a) Types of damages to mosaic tile sculpture artwork with concrete foundation, (b) Types of damages to mosaic tile sculpture artwork with steel foundation.

deterioration conditions of adhesives and tile manufacturing techniques, etc. for better preservation of tile sculpture artwork. Accordingly, this study aims to check the characteristics of the materials used in production, firing temperature of tile and manufacturing technique by conducting physicochemical analysis study on the tile sculpture artwork, “Ascending up the river against the current ...” exhibited in the sculpture park of Suwon World Cup Stadium. Results of this study could be utilized as basic data for restoration or reproduction of the original conditions of tile at the time of preservation of tile sculpture artworks.

## 2. SUBJECT AND METHOD OF ANALYSIS

### 2.1. Subject of analysis

A total of 50 sculptures including 40 artworks selected through “Open competition of outdoor sculptures by young artists” and artworks of 10 invited artists are exhibited in the sculpture park of Suwon World Cup Stadium established as a composite cultural and recreational venue at which sports, culture and arts are harmonized in commemoration of the FIFA Korea-Japan World Cup 2002 (Gyeonggi-do, 2002). The only tile sculpture artwork among the artworks exhibited in the sculpture park, “Ascending up the river against the current ...” by the artist Ji Yeong Kim, is an artwork that expressed the powerful image of mankind capable of overcoming and ascending out of any adversities through analogy to the tail of a fish. It is produced with overall dimension of 210 × 200 × 375 cm by pasting tiles onto the underlying artwork produced with concrete in mosaic format (Figure 2)(Gyeonggi-do, 2002).

Current condition of the artwork displays substantial phenomenon of detachment and exfoliation of the fillers between the tiles (Figure 3a) along with partial progression of exfoliation of tiles due to the aging of adhesive (Figure 3b). In addition, moss has set in the sections at which tiles, fillers and adhesives have been exfoliated along with settling in of mixed pollutants of soil, foreign matters and mosses, etc. at the bottom portion of the artwork, thereby damaging the original configuration and conveyance of the messages intended by the artwork (Figure 3c). It was confirmed that a total of 4 different types of tiles were used for this artwork and detached tile pieces are eroded or scattered in the soil at the bottom of the artwork exhibited. Some of these pieces were collected for use as analytic specimens in this study (Figure 4).

**Figure 2.** Artwork “Ascending up the river against the current ...” (artist: Ji Yeong Kim).


**Figure 3.** Preservation condition of the artwork “Ascending up the river against the current ...”. (a) Exposure of concrete surface due to exfoliation phenomenon of the tiles, (b) Phenomenon of detachment and exfoliation of fillers, and (c) Occurrence of biological damages at the sections of tile detachment.

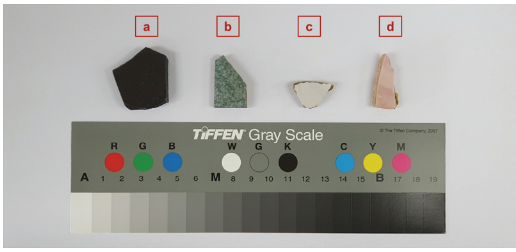


**Figure 4.** Tiles subjected to analysis. (a) Tile samples in black color range (hereinafter, a-t), (b) Tile samples in green color range (hereinafter, b-t), (c) Tile samples in white color range (hereinafter, c-t), and (d) Tile samples in red color range (hereinafter, d-t).

### 2.2. Analytic method

External and internal surfaces of the tile was repetitively measured 3 times to compute the average value by using spectrum colorimeter (CM-2600d, Minolta, JPN). After having completely removed the glaze layer on the specimen surface, and measured each of the weight taken after having completely dried the specimen over 2 days at 100 ± 5℃ (W1), weight after having removed all the surface moisture following immersion in distilled water for 2 days (W2) and weight while being immersed in water (W3), specific gravity (apparent and bulk), absorption rate and porosity by using precision electronic scale (AR2140, Ohaus, USA) and electronic gravimeter (SD-200L, Mirage, JPN) in accordance with the KS L 4008.

Observation of the cross-sectional structure was made by mounting the tile specimen with 2 liquid epoxy resin and then grinding the specimen surface with #400～#4000 sandpaper, abrasive cloth and grinder with the use of DP-Suspension solution. Specimen was prepared by removing foreign matters by replacing distilled water several times using ultrasonic cleaner after grinding, and observed and photographed under reflected light by using optical microscope (Axio ImagerA2m, Upright Microscope, Zeiss, Germany).

Components of the tile was analyzed by confirming the average value of the measurements taken on the tile sample that has been turned into powder state with analytic conditions of 20 kV, 68 $\mu$ A and spot size 60 by using X-ray fluorescence spectroscopy (ZSX Primus-II, Rigaku, JPN). Estimation of the key composition minerals of the clay and the firing temperature using them was made by means of X-ray diffraction analyzer (SmartLab, Rigaku, JPN) along with analysis of powdered specimen with Spinner under the measurement conditions of 45 kV, 40 mA, 6～70° and 0.02°/150 sec. For thermal analysis, clay was pulverized into powder after having removed the glaze layer, and caloric change (differential thermal) and change in thermal mass (thermogravimetry) in accordance with the temperature change were confirmed by using simultaneous thermal analyzer (SDT 2960, TA Instruments, GBR) by increasing the temperature in the range of 0～1400℃ at the increment of 20℃/min under the environment filled with $N_2$ gas by taking approximately 20 mg of the powdered specimen in order to indirectly estimate the firing temperature and physicochemical change of the clay used as the raw material for the tile.

## 3. RESULTS AND CONSIDERATIONS

### 3.1. Chromaticity analysis

Analytic value of chromaticity of tile was measured by using CIE LAB color space that indicates chromaticity with corresponding $a^*$ (green–red), $b^*$ (yellow–blue) and $L^*$(brightness) with the KS A 0067 (method of expressing color of object in accordance with L.A.B colorimetric system and L.U.V colorimetric system), which is a method of indicating color under the Korean Industrial Standards Ⓚ, as the standards. In addition, since 3 of the 4 types of samples with the exclusion of a-t tile have different colors for the outer surface and inner surface (main body), measurements were taken by distinguishing them (Table 1).

As the results of measurement, a-t tile for which the outer

**Table 1.** Result of color analysis of the sample

| Samples \ Color | | $L^*$ | $a^*$ | $b^*$ |
|---|---|---|---|---|
| a-t | Inner surface | 32.74 | 1.62 | 0.86 |
| | Outer surface | 32.35 | 1.14 | 0.44 |
| b-t | Inner surface | 57.11 | 4.56 | 8.38 |
| | Outer surface | 62.67 | -3.85 | -0.53 |
| c-t | Inner surface | 50.94 | 3.15 | 15.27 |
| | Outer surface | 93.95 | -0.24 | 0.17 |
| d-t | Inner surface | 49.12 | 2.75 | 14.69 |
| | Outer surface | 70.67 | 13.70 | 6.53 |

and inner surfaces are the same each of $L^*$ (outer surface 32.35, inner surface 32.74), $a^*$ (outer surface 1.14, inner surface 1.62) and $b^*$ (outer surface 0.44, inner surface 0.86) values were measured and similar chromaticity values were confirmed. However, the gloss on the outer surface is determined to be generated from the polishing process during the surface finishing procedure while the inner surface is estimated to have physical state of matt porcelain tile. b-t, c-t and d-t tiles are produced with the use of glaze and, as such, the inner surface and outer surface displayed physical states of ceramic tile that are different from each other. $L^*$ (outer surface 62.67, inner surface 57.11), $a^*$ (outer surface −3.85, inner surface 4.56) and $b^*$ (outer surface −0.53, inner surface 8.38) values were measured for b-t tile. $a^*$ value of the outer surface was confirmed to be −3.85, thereby illustrating the color value of green color range while the $b^*$ value of inner surface was confirmed to be 8.38, thereby confirming the color value of yellow color range.

$L^*$ (outer surface 93.95, inner surface 50.94), $a^*$ (outer surface −0.24, inner surface 3.15) and $b^*$ (outer surface 0.17, inner surface 15.27) values were measured for c-t tile. $L^*$ value of the outer surface is 93.95, illustrating high chroma, which is determined to be the result of surface color in white color range. $b^*$ value of inner surface is 15.27, which is the color value of yellow color range, thereby reconfirming that the outer surface and inner surface have colors that are different from each other. In addition, $L^*$ (outer surface 70.67, inner surface 49.12), $a^*$ (outer surface 13.70, inner surface 2.75) and $b^*$ (outer surface 6.53, inner surface 14.69) values were measured for d-t tile. Since $a^*$ value of the outer surface is confirmed to be 13.70, it displayed color value in the red color range while $b^*$ value of the inner surface is 14.69, which is the color value in the yellow color range, thereby leading to the presumption that it is an ceramic tile in red color range.

These measurements could serve as the basis for restoring tiles to their original form when conservation processing is performed on “Ascending up the river against the current ...”, which could help conservation processors and decision makers establish the preservation direction of the work.

## 3.2. Measurement of absorption rate, porosity and specific gravity

Apparent specific gravity, bulk specific gravity, absorption rate and porosity were measured for the 4 types of tiles (Table 2) and, as the results, a-t tile was found to have apparent specific gravity of 0.42, bulk specific gravity of 0.42, absorption rate of 0.46% and porosity of 1.10%. Based on such results, absorption rate of less than 3% is determined to be the range included in the standards of KS L 1001 (ceramic tile) for determination of porcelain tile. In addition, porosity measured to be 1.10% displayed low resultant value similar to the absorption rate due to small amount of pores given the characteristic of porcelain tile with high strength. As it can be confirmed from the chromaticity analysis results, the absorption rates of all of b-t, c-t and d-t tiles were found to be more than 10%, thereby leading to the presumption that they are ceramic tiles. This is a phenomenon that manifests due to occurrence of a lot of pores in ceramic tile at the time of manufacturing since it is fired at relatively lower temperature in comparison to that for porcelain tile. As such, it is possible to estimate the manufacturing process and tile types through the correlation manifested between porosity of more than 20% in proportion to the absorption rate.

## 3.3. Observation of cross-section

Cross-section was observed to check the extent of elutriation and magnetization of tiles through distribution appearance and formats of internal pores and crystals of clay used at the time of tile production, aspects of existence of

**Table 2.** Result of specific gravity and water absorption ratio and porosity of the sample

| Samples \ Analysis | Apparent specific gravity | Bulk specific gravity | Water absorption ratio | Porosity |
|---|---|---|---|---|
| a-t | 0.42 | 0.42 | 0.46 | 1.10 |
| b-t | 0.52 | 0.69 | 16.27 | 23.70 |
| c-t | 0.55 | 0.71 | 16.10 | 22.75 |
| d-t | 0.59 | 0.78 | 19.46 | 24.83 |

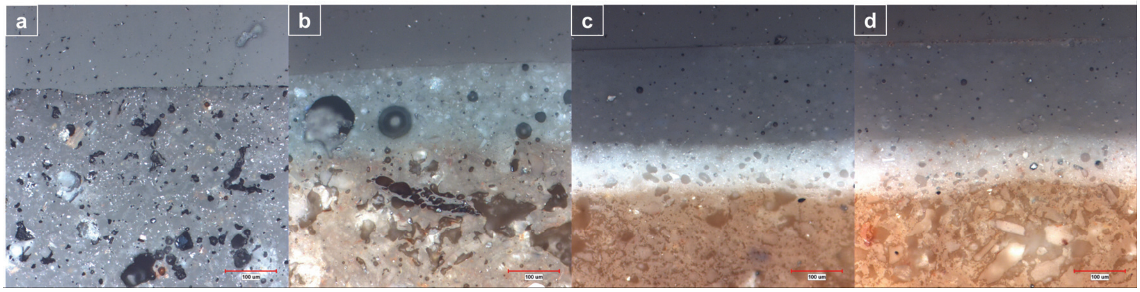


**Figure 5.** Result of a photograph of cross section of the sample. (a) a-t (× 200), (b) b-t (× 200), (c) c-t (× 200), (d) d-t (× 200).

air bubbles and crystals inside the glaze layer, etc. As the results of observation, the clay of a-t tile displays dense and compacted texture due to excellent hyalinization and is confirmed to be an unglazed tile with absence of glaze layer. This is a characteristic of porcelain tile, which is used mostly as an exterior tile due to its high strength and low absorption rate as the results of excellent hyalinization arising from high firing temperature (Figure 5a).

Although hyalinization occurred while the clay has been coated with glaze for b-t, c-t and d-t tiles, a lot of crystals that appear to be incompletely molten quartz or feldspar granules are observed inside the glaze layer along with widely spread minute air bubbles. This is presumed to be the result of the failure of air bubbles inside the glaze layer to be discharged due to rapid temperature increase and short firing period. Glaze layers of b-t, c-t and d-t tiles displayed green substrate, white substrate and light red substrate, respectively, thereby coinciding with the results of chromaticity analysis. The clay layers of b-t, c-t and d-t tiles display gray, brown and orange colored substrates, respectively. Moreover, although there exist some large quartz particles in all of 3 types of tiles, it is deemed that refined raw materials have been used for all the tiles since the shapes of the pores are not irregular and their sizes are small. Accordingly, it is presumed that the colors of the clays were consistently hyalinized and the pores have relatively less defects (Figure 5b∼d).

### 3.4. Fluorescent X-ray analysis

Component contents of the file were analyzed by classifying them into glaze layer and clay layer, and the results are given in Table 3 below. First, clay of a-t tile with no glaze layer contains $SiO_2$ 54.57 wt%, $Al_2O_3$ 28.61 wt%, $Fe_2O_3$ 9.39 wt%, $Na_2O$ 4.36 wt%, $K_2O$ 8.61 wt%, and MgO, CaO, $TiO_2$ and MnO in the range of 0.09∼0.89 wt%. Such results of analysis led to the presumption that silica, feldspar, mica and pottery stone, etc. were included in the raw materials used for the manufacturing of a-t tile. In particular, it was found that the contents of alumina is substantially higher than those of the other 3 tiles, thereby leading to the presumption that kaolin is included in the clay. Kaolin, unlike other clay, is a silicate range mineral that can withstand high temperature of more than 1300℃ very well and, as such, is used extensively as the raw material for earthenware and ceramics. It was possible to confirm the correlation that coincides with the results of thermal analysis executed in this study.

It was confirmed that clays for b-t, c-t and d-t tiles contained $SiO_2$ 54∼59 wt%, $Al_2O_3$ 14∼15 wt%, $Fe_2O_3$ 3 wt%, $Na_2O$ 0.6∼2 wt%, $K_2O$ 6∼9 wt%, CaO 14∼15 wt%, and MgO, $TiO_2$ and MnO in the range of 0.1∼1.5 wt%. Based on this result, it can be determined that the raw material used in the tile production is a clay containing feldspar, silica and pottery stone, etc. Moreover, since CaO contents is detected to be higher than that of a-t tile, it is presumed that raw material containing lime was used. In addition, the glaze layer of b-t, c-t and d-t tiles contained $SiO_2$ 50∼51 wt% and $Al_2O_3$ 15∼17 wt%, thereby leading to the presumption that pyrophylite is one of the minerals included in the glaze. Pyrophylite is used extensively as a material for glaze treatment of tile substrate and plays the role of reducing thermal expansion, moisture expansion and cracks that the tile experiences. Detection of other minerals including CaO (14∼15 wt%), $K_2O$ (2∼3 wt%) and MgO (0.8∼1.5 wt%) in the order of the quantity of their contents thereof leads to the presumption that glaze containing dolomite was used. This is used extensively in hardened tile

**Table 3.** Result of inorganic component of the sample

| Samples \ Analysis | | Elements (wt%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | $SiO_2$ | $Al_2O_3$ | CaO | $Na_2O$ | $Fe_2O_3$ | MgO | $K_2O$ | $TiO_2$ | MnO |
| a-t | Glaze | - | - | - | - | - | - | - | - | - |
| | Body | 54.57 | 28.61 | 0.89 | 4.36 | 9.39 | 0.29 | 8.61 | 0.51 | 0.09 |
| b-t | Glaze | 51.12 | 17.03 | 14.90 | 0.34 | 2.87 | 1.55 | 2.78 | 0.31 | 0.05 |
| | Body | 59.41 | 14.21 | 15.08 | 2.28 | 3.54 | 1.54 | 9.85 | 0.59 | 0.15 |
| c-t | Glaze | 50.60 | 16.43 | 14.11 | 0.45 | 1.72 | 0.98 | 3.41 | 0.21 | 0.04 |
| | Body | 54.75 | 14.85 | 14.65 | 1.04 | 3.68 | 0.41 | 6.08 | 0.71 | 0.11 |
| d-t | Glaze | 51.32 | 15.12 | 15.05 | 0.34 | 2.16 | 0.85 | 3.24 | 0.16 | 0.19 |
| | Body | 56.12 | 15.34 | 15.57 | 0.69 | 3.18 | 0.47 | 6.57 | 0.29 | 0.12 |

and as a substitute for limestone since it can increase the firing speed by promoting reaction with feldspar, silica and clay if dolomite is mixed with substate that contains feldspar.

### 3.5. X-ray diffraction analysis

Results of analysis by identifying the compositional minerals through X-ray diffraction analytic method and estimating the firing temperature through such identification are presented in the Figure 6 below. As the results of confirmation of compositional minerals, all the clay minerals of a-t tile became extinct and quartz, mullite and cristobalite were identified, thereby leading to the presumption that the tile would have been fired at the temperature higher than 1200℃. Such high temperature firing is correlated with high level of magnetization of clay and, as illustrated in the results of cross-sectional observation, would have affected the generation of cristobalite due to extensive progress of hyalinization (Figure 6a).

Quartz and mullite were identified for b-t, c-t and d-t tiles with all the clay minerals becoming extinct. As such, it can be presumed that all these tiles were fired at similar temperatures of approximately 1100℃. From these results, it is deemed that distinction can be made between porcelain tile and ceramic tile in accordance with the firing temperature in the manufacturing of the tiles (Figure 6b∼d).

### 3.6. Thermal analysis

Diversified minerals mixed in the clay display thermal behaviors in accordance with their respective physicochemical characteristics depending on the temperature and pressure conditions at the time of firing the tile, and, as such, the firing temperature and characteristics of tiles were estimated through such thermal behaviors. As the results of analysis, the heat absorption peak observed at temperatures below 200℃ is determined to be due to evaporation of water physically adsorbed onto the specimen surface, while pyrogenic peak due to partial disintegration with beginning of melting through reaction between part of silica ($SiO_2$) and other minerals was observed in the thermal absorption peak manifested in the temperature range of 700∼900℃.

Changes in mullite are observed in the temperature range of 950∼1000℃ in all 4 tile types with display of thermal absorption peak in a wide temperature range of 1100∼1200℃, which is the result manifested due to hyalinization of

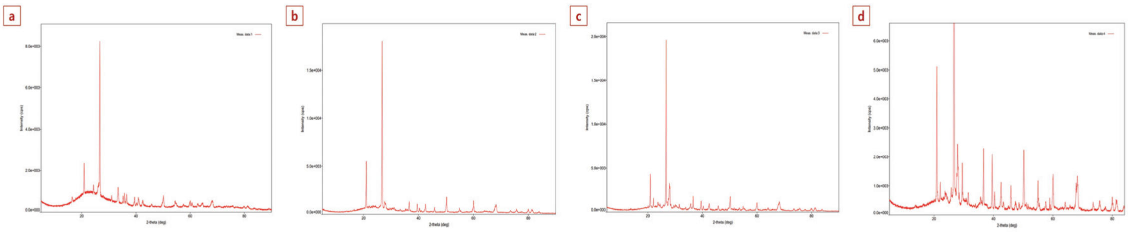

**Figure 6.** Result of X-ray diffraction analysis of the sample. (a) a-t, (b) b-t, (c) c-t, (d) d-t.

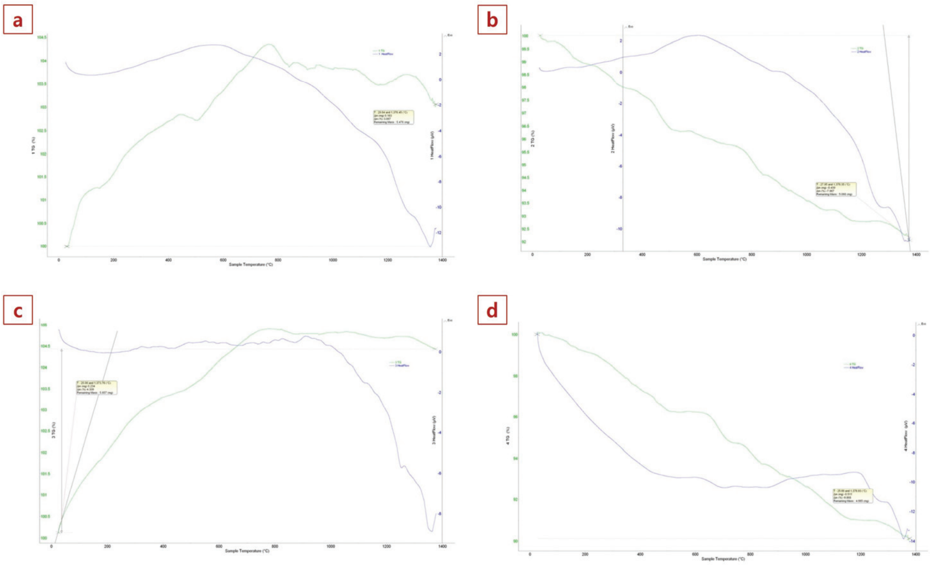


**Figure 7.** Result of TG-DTA analysis of the sample. (a) a-t, (b) b-t, (c) c-t, (d) d-t.

clay arising from the melting of quartz, etc. It is estimated that b-t, c-t and d-t tiles were fired at temperatures below 1200℃. In the case of a-t tile, since the appearance of thermal absorption that occur lowly and slowly after having reached the temperature of 1200℃ was observed, thereby signifying that the temperature range for thermal absorption peak is very high at 1100～1250℃ and caloric value being absorbed is very large. Accordingly, it is determined that a-t tile has the property of porcelain tile for which hyalinization occurs extensively (Figure 7a～d).

## 4. CONCLUSION

This is a basic study on the artwork “Ascending up the river against the current ...” of the artist Ji Yeong Kim being exhibited in the sculpture park of Suwon World Cup Stadium and tiles of the said artwork was analyzed through scientific analytic method. The current conditions of the artwork include contamination of pasted tile due to diversified environmental factors and damages to the original configuration of the artwork due to detachment of tile arising from aging of adhesive used to paste the tiles. In addition, shattering of the tiles and cracks in the glaze layer, etc. are making restoration of the materials used for the artwork difficult in the future. Accordingly, this study was conducted to secure basic data of artwork undergoing continuous damages with passage of time by being exposed to outdoor environment and the following conclusions were deduced.

It was confirmed that the tiles used for the production of the artwork can be classified into 2 types, namely, porcelain tile and ceramic tile, and it is determined that it was produced by applying mosaic technique by cutting tile and pasting tile onto the concrete underlying structure with adhesive and joint sealant for the tiles. Tile in black color range (a-t tile) for forms the overall background of the artwork is a porcelain tile with the same outer and inner surfaces without the presence of glaze layer. Moreover, it was confirmed through visual and microscopic cross-sectional observation that the porcelain tile was produced with glossy outer surface through polishing process. In addition, results of component analysis, thermal analysis and identification of minerals, etc. support the presumption that the tile has 0.4% absorption rate and experienced firing at a high temperature of more than 1,30 0℃. Porcelain tile is used mostly as floor or exterior tile due to its high strength and low absorption rate arising from very high firing temperature. In the case of unglazed tile used for this artwork, it was fired once without the application of glaze. It is deemed that such porcelain tile would have been a material for use in the production of outdoor tile sculpture artwork due to its outstanding water resistance, durability and wear resistance, etc.

3 types of tiles are used for the portion of the artwork presumed to have embodied the tail of a fish as the intent of the artwork and the artist, It is confirmed that these are

ceramic tiles with different physical states between the outer and inner surfaces, and with presence of glaze layer. The colors of the tiles are in white, green and red ranges, and it was confirmed that they have absorption rate of more than 10% and experience of having been fired in the temperature range of 1,000～1,200℃ through thermal analysis and identification of minerals. In addition, it was estimated through component analysis and cross-sectional observation of the glaze layer that these tiles are manufactured through 2nd firing executed by using glaze containing minerals in pyrophyllite or dolomite range following the 1st firing. Such manufacturing technique is used widely in the production of mosaic tile sculpture artwork due to high economic value and ease of producing diversified colors and patterns since the firing temperature is relatively low. However, ceramic tile, due to its relatively lower firing temperature in comparison to that of porcelain tile, has low strength and high absorption rate. As such, it is not appropriate as a material for outdoor tile sculpture artwork since cracks can occur due to repetitive freezing and thawing if used as an exterior material. However, it is deemed that it can sufficiently perform its function as a material for artwork by retaining diversified patterns and colors continuously if continuous care for preservation of tiles is provided.

Although there was difficulty in making quantitative comparison of the results of analysis of the artwork “Ascending up the river against the current ...” due to the absence of preceding study, it is deemed that this study is meaningful in having secured basic data to be used as reference in selecting the materials and establishing the directionality for preservation measures from the perspective of preservation management of artworks in the future. It would be necessary to pursue continuous studies on the preservation materials and technologies along with securing of basic data through such scientific analytic works at the same time in the future. It is anticipated that data secured through this study could be utilized in preservation of and restoring the message to be conveyed by the artwork while maintaining the intention of the artist and originality of the artwork if system for simultaneous accomplishment of communication, cooperation and research activities, etc. with the actual decision makers such as the artist, foundation or assistant, etc. can be introduced and adopted.

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