

Painted clay sculpture in Shanxi Province: Material analysis of the Tutang Buddha and two attendants in Jingyin Temple, Taiyuan

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Abstract

There are more painted clay sculptures in Shanxi Province than in any other province in China. These fine relics, dating from the Sui and Tang dynasties to the Ming and Qing dynasties, are important to the study of ancient sculpture in China. We investigated the Tutang Buddha (from the Jin dynasty) and two attendant bodhisattvas (from the Ming dynasty) in the Buddha Pavilion of the Jingyin Temple in Taiyuan. The Tutang Buddha was the first clay Buddha in Jinyang (now Taiyuan). According to the inscription, the Tutang Buddha was carved out of the hill. Our onsite investigation revealed that there were coarse and fine layers of clay mixed with wheat straw. It is clear that the construction of the Tutang Buddha is different with the traditional painted clay sculpture. The two attendant bodhisattvas are the traditional painted clay sculptures, which consist of a wood framework covered with layers of coarse clay, fine clay, white ash, paper and pigments. Damaged sections of the painted sculptures were visually examined, sampled and subsequently analysed. All three sculptures have been repainted at least twice. The material samples were analyzed using scanning electron microscopy, energy dispersive spectrometry, Raman spectroscopy, X-ray diffraction, biological microscopy, and particle size analysis. The analysis enabled us to infer the techniques used by the creators of the sculptures. This research provides a foundation for the conservation and future protection of these and similar sculptures.

Introduction

China has thousands of years of history and is renowned for the diversity of its sculpture art. Traditional Chinese sculpture is made from ceramics, wood, bone, metal, clay, and many other materials. Painted clay sculptures in temples form a distinct class of artifacts. Religious statues mostly represent figures from history and from spiritual communities, such as Buddhism or Taoism, or local deities from myth and folklore.[1] There are many painted clay statues in China, and Shanxi Province is home to most of them. There are 12,712 painted sculptures and relics in Shanxi Province, dating from the Sui and Tang dynasties to the Ming and Qing dynasties. Surviving works provide important material for the study of ancient Chinese sculpture. The most prominent of these artworks are perfect combinations of religious and folk arts and include the painted sculptures of Pingyao Shuanglin Temple, Pingyao Zhenguo Temple, and Jingcheng Qinglian Temple.[2]

Current studies of the traditional sculpture are mainly concerned with the artistic style of painted sculpture[3–9]. Despite studies of the painted sculptures of Foguang Temple[10], Chunyang Palace[11], the Dunhuang caves[12, 13], Jiexiu Houtu Temple[14], Qinglian Temple[15] and others[16–19], research into construction materials, coupled with the conservation, protection, and restoration of painted sculptures, remains limited. Many painted sculptures have suffered damage due to the environments in which they have survived and have serious problems from pollution, peeling pigments, and collapse. We investigated three painted sculptures in the Buddha Pavilion of Jingyin Temple, Shanxi Province, that are in urgent need of conservation.

Jingyin Temple, also known as the Tutang Buddha Temple, is located on a hillside, 20 kilometers northwest of Taiyuan in Shanxi Province. Jingyin Temple, which is over 800 years old, was built during the Northern Qi dynasty and rebuilt in 1205. The stone tablets in Jingyin Temple show that the temple was rebuilt many times during the Ming dynasty, and that some of its buildings were repaired during the reigns of the Daoguang Emperor and the Guangxu Emperor during the Qing dynasty. In 2006, Jingyin Temple was declared a nationally important cultural relic by the State Council.

The Buddha Pavilion is the most important building in Jingyin Temple (Fig. 1(a),(b)). The pavilion, built on a cliff, is an east-facing two-story building with a double-eaved hip-and-gable roof. There are three painted sculptures in the hall of the Buddha Pavilion. The solemn-faced statue sitting on a raised platform is the Tutang Buddha Amitabha (Fig. 1(c)), and standing, one on each side of the Buddha, are statues of the Mahasthamaprapta bodhisattva (Fig. 1(d)) and the Avalokitesvara bodhisattva (Fig. 1(e)). The Tutang Buddha is 9.46 m tall and covered with gold paint. The bare-chested Buddha wears a robe and sits on a lotus seat with his hands in his lap.

The name of Jingyin Temple originated in the twentieth year of the reign of the Jiajing Emperor during the Ming dynasty (1541). It is recorded in the Document of the Rebuilding of the Tutang Pavilion that there was a hill piled with loess which suddenly collapsed into a cave. Inside the cave, a 33.3 m mound was seen, which looked like a Buddha. It was sculpted into a statue by the local people. The Tutang Buddha is one of the two Buddhas built with clay in Shanxi Province. It was the first clay Buddha in Jinyang (now Taiyuan) and, with distinctly local characteristics, it offers a rare opportunity to study the commingling of Buddhism in China with the culture of the Loess Plateau.[20] Avalokitesvara bodhisattva and Mahasthamaprapta bodhisattva stand opposite to each other. They are both 3.7 m tall and have broad, plump faces, which are white as jade; they have a gentle and beautiful appearance. They both wear necklaces and bracelets, as well as ornate clothes. A literature search determined that the bodhisattvas are painted sculptures from the Ming dynasty.

In our study, scanning electron microscopy, energy dispersive spectrometry, Raman spectroscopy, X-ray diffraction, biological microscopy, and particle size analysis were used to investigate the making materials and craft of the painted sculptures in Jingyin Temple. This study is of great significance in understanding the transmission and development of the traditional sculpture techniques used in creating these statues. Analysis of the materials used and the construction techniques of the statues is also required for their conservation, so our study can direct the restoration of the painted sculptures in Jingyin Temple.

Experimental

Samples

Samples were taken from the damaged areas of the three painted sculptures, mainly the pigment, paper, and fine clay layers, following the procedures given in *Principles for the Conservation of Heritage Sites in China*. The *Principles* restrict sampling to visible surfaces; thus the coarse clay layers and wooden frames

of the statues were not sampled. A small amount of undisturbed soil from the mountainside of the Juewei Mountain where Jingyin Temple is located was also taken as a sample for comparison. The sample details are given in Table 1.

Pigment identification

Three instruments were used in sample analysis: an inVia confocal Raman microscope, equipped with a Leica microscope and a 50× objective lens, using two (532 nm and 785 nm) of the three lasers with 1 μm spot size and a spectrum test range 100–3000 cm⁻¹; and a Thermo-Fisher Scientific scanning electron microscope (SEM) FEI Quanta650 with an Oxford Instruments X-maxN50 energy dispersive spectrometer (EDS).

Each sample was fixed to the sample holder with conductive adhesive. After compaction, an ear syringe was used to blow away any loose dust. The surface of the sample was coated with gold, and some samples were coated with carbon. Aztec software was used in the point & ID mode for micro-analysis. The acceleration voltage was 20.00 kV, the working distance was 10 mm, and the magnification was not fixed.

Clay analysis

Two instruments were used in sample analysis, a rotating target X-ray diffractometer (Japan Makco Corporation MXPAHF 18 kW) and a laser particle size distribution analyzer (Bettersize Instruments Ltd. BT-9300S). The scanning range of the diffraction angle was 10°–70°; the working voltage was 40 kV, and the working current was 200 mA. The scanning speed was 8°/min, and the scanning step was 0.02.

Particle analysis of the clay samples was conducted. Plant fiber was removed from a sample by suspension and heating to minimize interference from fibers in the clay on particle size determination. The sample was then sonicated for 3 min to avoid sample reaggregation. The laser particle size analyzer was used to measure the ratio of total particle volume to total volume of all samples in a particular size range.

Paper analysis

A Leica DM2500 biological microscope was used to analyze paper samples. The sample was dispersed into single fibers and placed on a microslide. Two drops of iodine–zinc chloride staining agents were put on the fibers. A fiber-measuring instrument was used to observe fiber morphology and to identify the type of paper.

Results And Discussion

Manufacturing technique

There are no records of the manufacturing techniques used to create the painted clay sculptures in the Buddha Pavilion of Jingyin Temple. This investigation is intended to record details of the basic structure and the painted layers, and other information about the sculptures, by onsite observation and sample analysis of the damaged surfaces and sections of the sculptures.

(1) Tutang Buddha

The Tutang Buddha is a sculpture representing Amitabha. According to the inscription (*Records of the Tutang Pavilion Reconstruction in the twentieth year of the reign of the Jiajing Emperor in the Ming dynasty, 1541, and inscriptional record of re-gilding the statues of Buddha in the fourth year of the reign of the Qianlong Emperor in the Qing dynasty, 1739*) [20], the Tutang Buddha was carved out of the hill. Observation of the damaged part of the sculpture (the finger, the clothes and the lotus) indicates that there were coarse and fine layers of clay mixed with wheat straw. Obviously, the construction of the Tutang Buddha is different with the traditional technique of the painted sculpture.

The Tutang Buddha's whole body is gilded, with the hair painted in blue. The inner clothing is red, and the exterior is golden, which emphasizes the three-dimensionality of the figure. The lotus seat is red, which is one of the five superior colors traditionally used in ancient sculpture and painting. It is found that the gilded surface is painted with exquisite blue pattern (Fig.2(a)), at the belt of the sculpture. The traditional LiFen technique is applied in drawing intricate patterns at the edge of the dress (Fig.2(b)). Unfortunately, it is impossible to know the full view of the Tutang Buddha, because of the flaking of the surface paint layer and the contaminants covered on the sculpture.

There are at least two layers of heavily applied paint. The outermost layer (Fig.2(c)) of paper on the Buddha's face, which covers the original red pigment, was gilded after being glued. The surface layer of the lotus seat (Fig.2(d)) is red, and the underlying layer is green.

(2) The two bodhisattvas

The style of the painted sculptures of the bodhisattvas on either side of the Tutang Buddha dates them from the Ming dynasty. Thus they are later than the Tutang Buddha. Observation of the damaged part of the sculpture (the internal timber framing was not exposed to the air, and so could not be sampled) indicates that construction also used the traditional technique of creating a wooden frame covered by layers of coarse clay, fine clay, lime, paper, and paint. The two bodhisattva sculptures had been repainted but not reshaped (Fig.3(a),(b),(c)).

Analysis of construction materials

(1) Pigment analysis

The gold, red, black, blue, green, and white paint samples from the three sculptures were analyzed using Raman spectroscopy and SEM/EDS (Fig 4-1, 4-2, 5-1, 5-2).

The results (Table 2) show that the gold foil on the surface of the Tutang Buddha is Au, the lime layer is calcium carbonate, and the red pigment is a mix of cinnabar and minium. On the Mahasthamaprapta bodhisattva, gold foil on the surface of the statue is Au, the red pigment is a mixture of cinnabar and minium, and the blue pigment is azurite. On the Avalokitesvara bodhisattva, gold foil on the surface of the statue is Au, and the green pigment is atacamite. Analysis of some pigments was inconclusive because of environmental damage, and further analysis is needed.

(2) Ground layer analysis

It is clear to the naked eye that the outermost layers of paint on the Buddha and the two attendants are painted on paper. The paper fibers were viewed through a biological microscope (Fig.6 (a),(b),(c)). The fibers in the outermost paper of all three statues were found to be ramie[28,29]. We infer that the three statues were likely to have been refinished at the same time, with the same materials being used.

(3) Clay layer analysis

Component analysis

Only samples of painted clay layers were taken for testing because of technical restrictions on sampling historical artifacts. XRD analysis showed that the composition of the painted clay layers was very similar in all three statues. The fine clay layers of the two attendants are identical; they contain calcite, gypsum and soda feldspar. The fine clay layer of the Tutang Buddha contains silica, calcite and soda feldspar.

We collected some deep-buried soil from the hillside close to Jingyin Temple to compare its composition with the clay layers of the statues. The analysis showed that the local soil, which contained silicon dioxide[30], calcite[31], and calcareous feldspar, is similar in composition to the fine clay layers of the sculptures in the Buddha Pavilion. This result suggests that there is an authentic local source of repair material for filling and grouting the sculptures.

(4) Particle size analysis

A laser particle size analyzer was used to create particle size distributions of the local soil samples and the fine clay layers of the three sculptures. The distributions were calculated using the Chinese particle size grouping (Table 3).

The particle size of the fine clay layers of the three sculptures is mainly distributed in the range 0.0002–0.20 mm, covering the clay, powder, and sand particle groups. Coarse powder accounts for >50%, followed by clay particles and fine powder particle. The smallest proportion is fine sands. When these results are considered together with the XRD analysis, we see that the fine clay layers of the three sculptures are similar in composition and are little different from the local soil. We conclude that the materials used to create the painted clay sculptures were obtained locally.

Conclusion

Painted sculpture is an art form that combines sculpture with painting. We researched the techniques and materials used to create the Jin dynasty Tutang Buddha and the Ming dynasty Mahasthamaprapta bodhisattva and Avalokitesvara bodhisattva. The Tutang Buddha is known as the first clay Buddha in Jinyang. According to the inscription, the Tutang Buddha was carved out of the hill. Our onsite investigation revealed that there were coarse and fine layers of clay mixed with wheat straw. Our results show that the construction of the Tutang Buddha is different with the traditional painted clay sculpture. The two attendant bodhisattvas are composed of a wooden frame covered by layers of coarse clay, fine clay, white ash and paper, that was painted. The technique used in construction of the two attendant bodhisattvas is a traditional method of creating painted clay sculptures. All three sculptures had been repainted at least twice, which is consistent with the records of repair recorded in the Ming dynasty.

The gold foil used on the three painted sculptures consists of Au. Red pigment is a mixture of cinnabar and minium; green pigment is chlorite; blue pigment is azurite; the white-gray layer is calcium carbonate. The clay used in the fine clay layer was obtained locally and is composed mainly of the minerals silica, calcite, and sodalite.

This research helps us to understand the molding techniques and styles of local craftsmen at the time the statues were created and thus has an important place in the heritage of China's traditional painted sculptures. Restoration work can be guided by this increased understanding of the design and manufacturing techniques of ancient clay sculptures.

Declarations

Availability of data and materials

The datasets analyzed during the current study are available from the corresponding author on reasonable request.

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Contributions

Xiaojian Bai designed the experiment; prepared the samples; performed the data analysis; wrote the manuscript. Chen Jia and Zhigen Chen provided the samples and interpreted the information of statues restoration; helped for writing and revised the article. Huwei Cheng provided the photographs of the sculptures; revised the article. Jiayue Wang participated in completing part of the analysis.

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Ethics declarations

Competing interests

The authors declare that they have no competing interests.

Additional information

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Tables

Table1. Sample information.

Number	Sample No.	Sculpture	Sample name	Sampled section
1	JYS-1-1	Tutang Buddha	Golden surface	Lower part of the left side of Buddha
2	JYS-1-2	Tutang Buddha	Red pigment	Below the left sleeve of Buddha
3	JYS-1-3	Tutang Buddha	Red pigment	Lower part of the right side of Buddha
4	JYS-1-4	Tutang Buddha	Lime layer	Lower part of the right side of Buddha
5	JYS-1-5	Tutang Buddha	Fine clay layer	Expose part of plastic clay (around the legs)
6	JYS-1-6	Tutang Buddha	Black pigment	Lower part of the right side of Buddha
7	JYS-2-1	Mahasthamaprapta bodhisattva	White pigment	Right sleeve of sculpture
8	JYS-2-2	Mahasthamaprapta bodhisattva	Golden	Left sleeve of sculpture
9	JYS-2-3	Mahasthamaprapta bodhisattva	Red Pigment	Kasaya of the sculpture
10	JYS-2-4	Mahasthamaprapta bodhisattva	Dark-blue pigment and paper in sublayer	Kasaya of the sculpture
11	JYS-2-5	Mahasthamaprapta bodhisattva	White pigment	Kasaya of the sculpture
12	JYS-2-6	Mahasthamaprapta bodhisattva	Fine clay layer	Fine clay layer's plastic soil after the sculpture's feet
13	JYS-3-1	Avalokitesvara bodhisattva	Green pigment and papers in sublayer	Around the hemline of the left side of Buddha
14	JYS-3-2	Avalokitesvara bodhisattva	Golden	Around the hemline of the left side of Buddha
15	JYS-3-3	Avalokitesvara bodhisattva	Black pigment	Around the hemline of the left side of Buddha
16	JYS-3-4	Avalokitesvara bodhisattva	Fine clay layer	Fine clay layer's plastic soil after the sculpture's feet
17	JYS-4	Mountain soil sample		

Table 2. Analysis of pigments in the paint layers of the sculptures.

Number	Sample No.	Sample description	Raman spectrum peak (cm ⁻¹)	SEM/EDS	Pigment analysis
1	JYS-1-1	Gold foil and paper in sublayer	/	Au	Au
2	JYS-1-2	Red pigment	252, 287, 346	Pb, Hg	Cinnabar[21,22]; minium may also be included
3	JYS-1-3	Red pigment	-	Pb	Most likely to be minium
4	JYS-1-4	Lime layer	152, 278, 1087	Ca	CaCO ₃ [23]
5	JYS-1-6	Black pigment	-	-	-
6	JYS-2-1	White pigment	142,448,975	Pb	-
7	JYS-2-2	Golden	/	Au	Au
8	JYS-2-3	Red pigment	252,286,342 160,225,313,475,546	Pb, Hg	Mix of cinnabar and minium[24,25]
9	JYS-2-4	Dark-blue pigment	137, 174, 247, 400, 543, 766, 836, 944, 1096, 1348, 1425, 1581	Cu	Azurite[26]
10	JYS-2-5	White pigment	446, 612, 639, 973, 1051	Pb	-
11	JYS-3-1	Green pigment	360, 514, 825, 915, 981	Cu	Atacamite[27]
12	JYS-3-2	Golden	/	Au	Au
13	JYS-3-3	Black pigment	-	-	-

Table 3. Particle size distribution of the fine clay layer.

Sample Name	Particle size (mm)	Coarse sand	Medium sand	Fine sand	Coarse powder particle	Fine powder particle	Clay particles
	Ratio (%)	$0.5 < d \leq 2$	$0.25 < d \leq 0.5$	$0.075 < d \leq 0.25$	$0.01 < d \leq 0.075$	$0.005 < d \leq 0.01$	$d \leq 0.005$
JYS-4	/	/	/	6.17	58.03	16.56	19.24
JYS-1-5	/	/	/	8.45	60.24	15.29	16.02
JYS-2-6	/	/	/	8.67	62.21	14.82	14.30
JYS-3-4	/	/	/	7.89	61.45	15.63	15.03

Figures

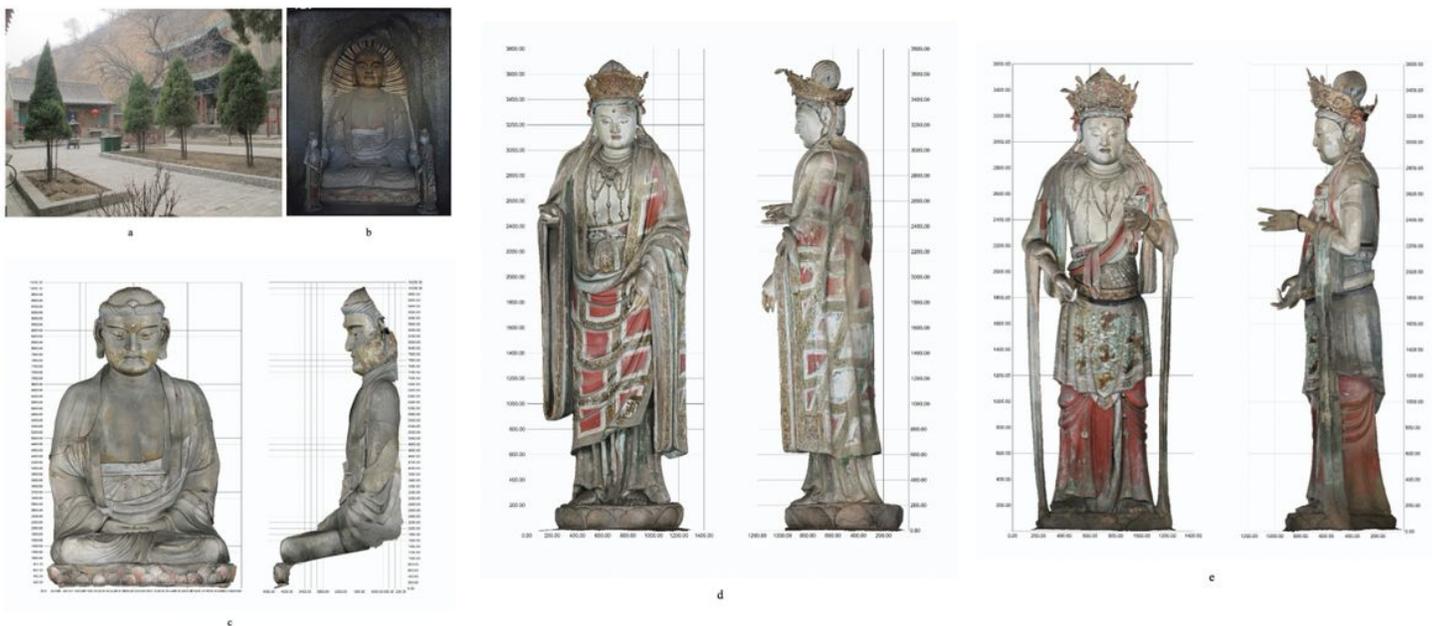


Figure 1

General view of the temple and sculptures of The Buddha Pavilion.(a) the interior of the Jingyin Temple; (b) the interior of the Buddha Pavilion;(c) Sculpture of Tutang Buddha;(d) Sculpture of Mahasthamaprapta bodhisattva on the left side of Tutang Buddha;(e) Sculpture of Avalokitesvara bodhisattva on the right side of Tutang Buddha.



a



c



b



d

Figure 2

(a) The exquisite blue pattern painting on the gold; (b) The intricate patterns at the edge of the dress; (c) Repainting on the lower part of the face of the Tutang Buddha; (d) Repainting on part of the lotus seat.



a



b



c

Figure 3

(a) Repainting on part of the Avalokitesvara bodhisattva sculpture; (b) Repainting on part of the Avalokitesvara bodhisattva's base; (c) Repainting on part of the Mahasthamaprapta bodhisattva.

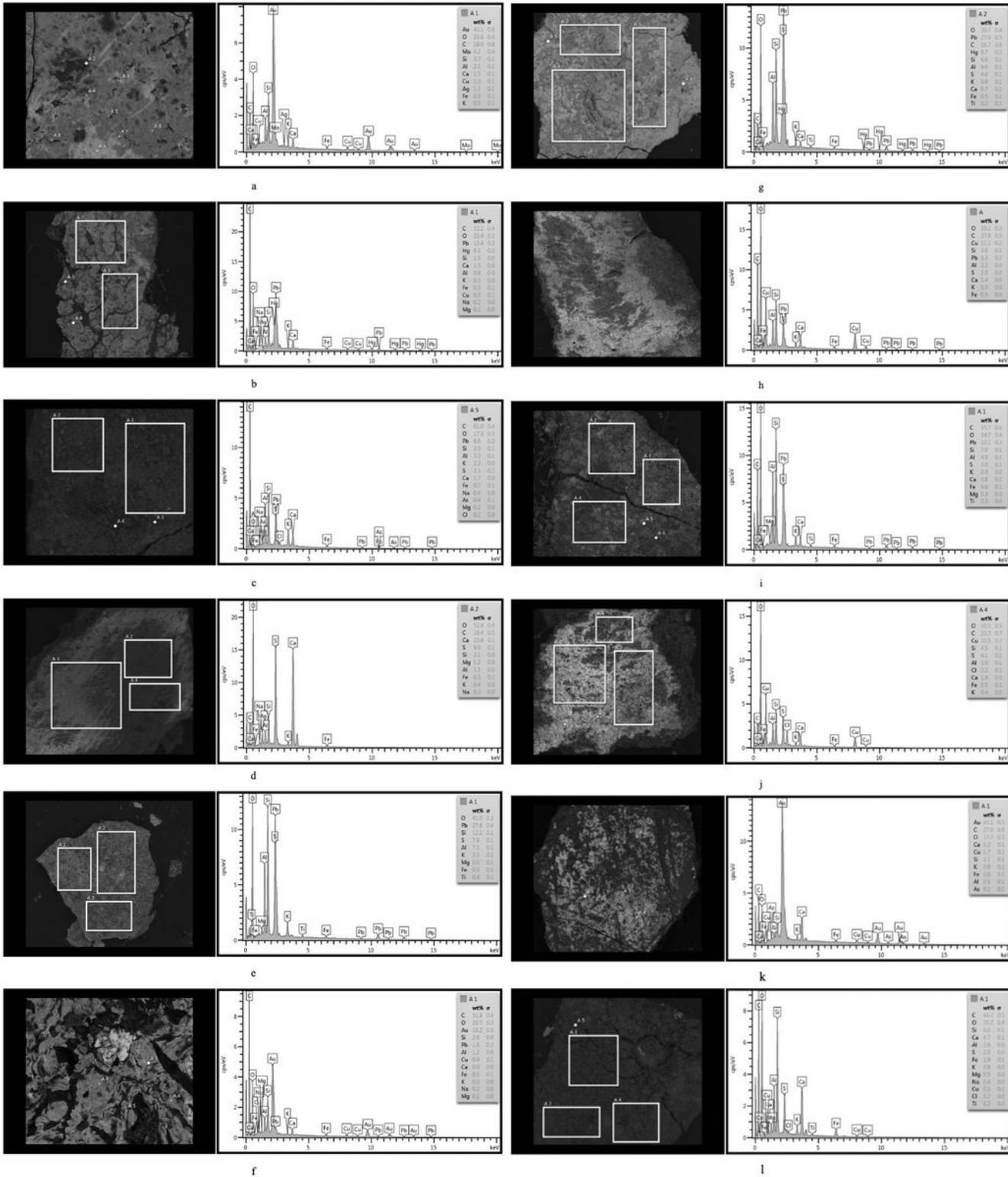


Figure 4

SEM/EDS results of the samples:(a) JYS-1-1;(b) JYS-1-2;(c) JYS-1-3;(d) JYS-1-4;(e) JYS-2-1;(f) JYS-2-2;
 (g) JYS-2-3;(h) JYS-2-4;(i) JYS-2-5;(j) JYS-3-1;(k) JYS-3-2;(l) JYS-3-3.

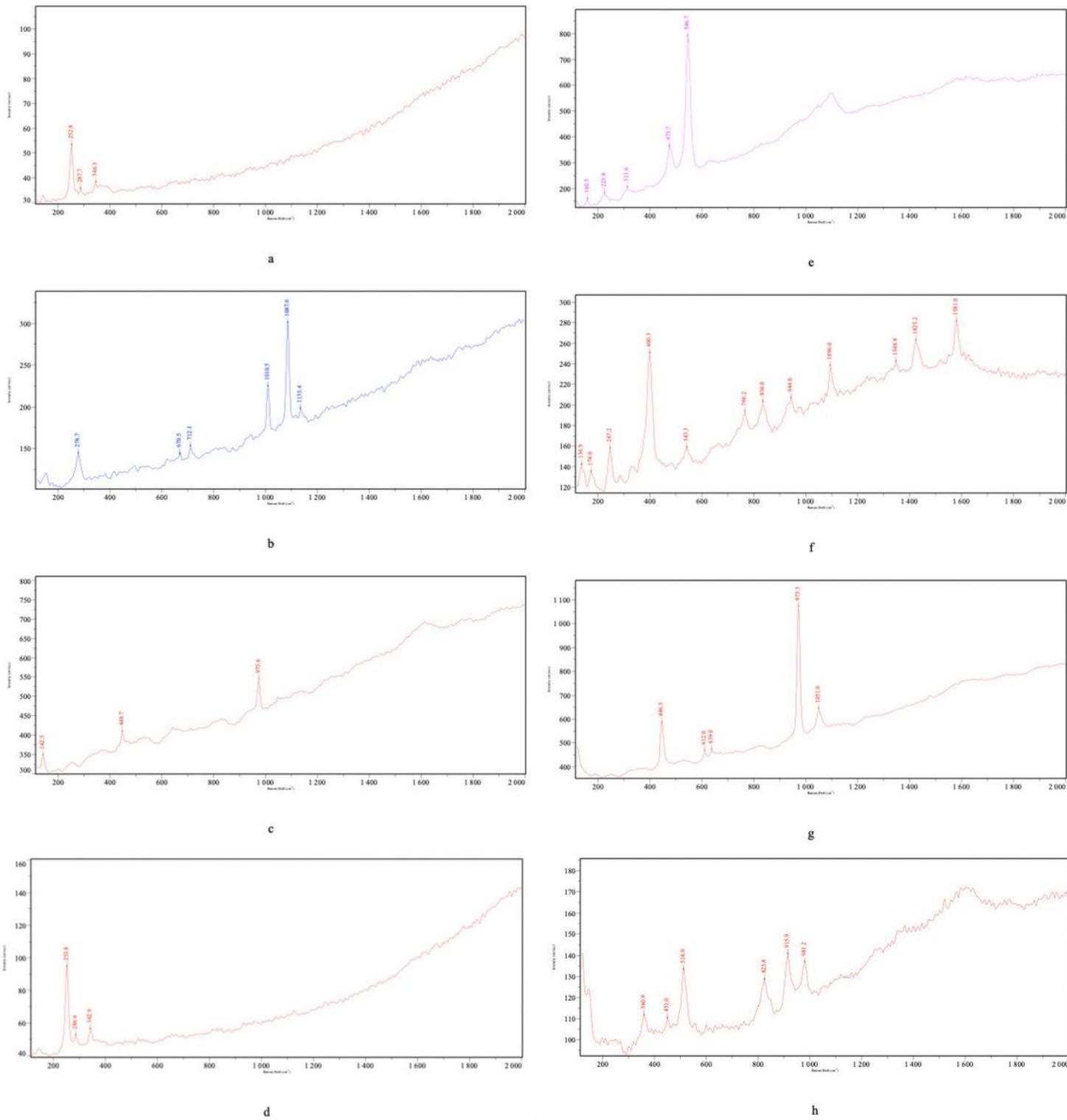
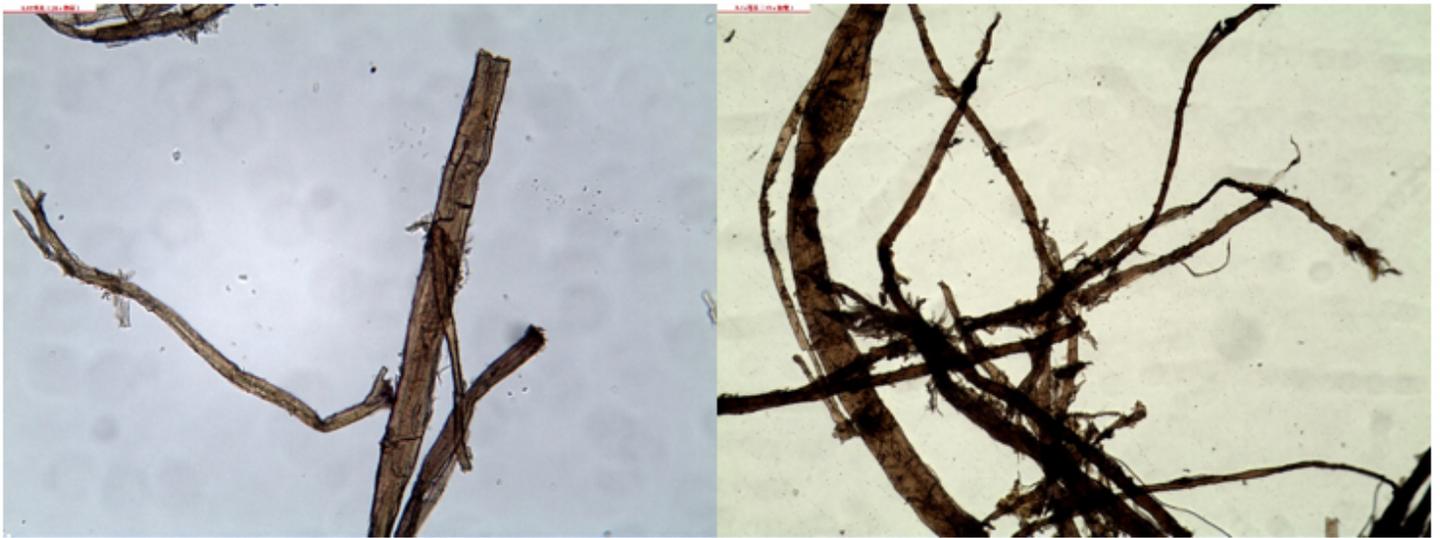


Figure 5

Raman spectrum of samples: (a) JYS-1-2; (b) JYS-1-4; (c) JYS-2-1; (d) JYS-2-3-1; (e) JYS-2-3-2; (f) JYS-2-4; (g) JYS-2-5; (h) JYS-3-2.



a

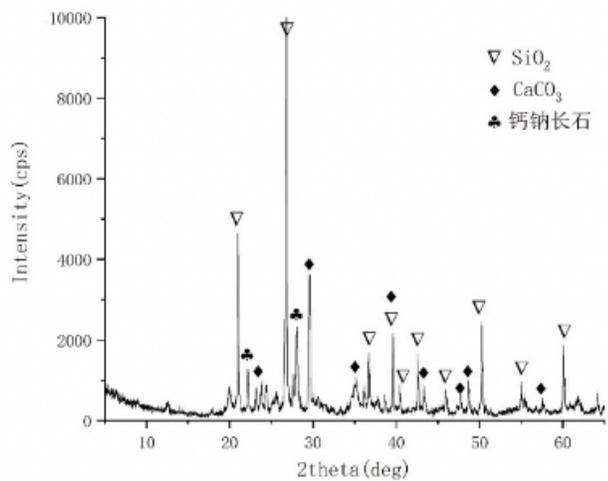
b



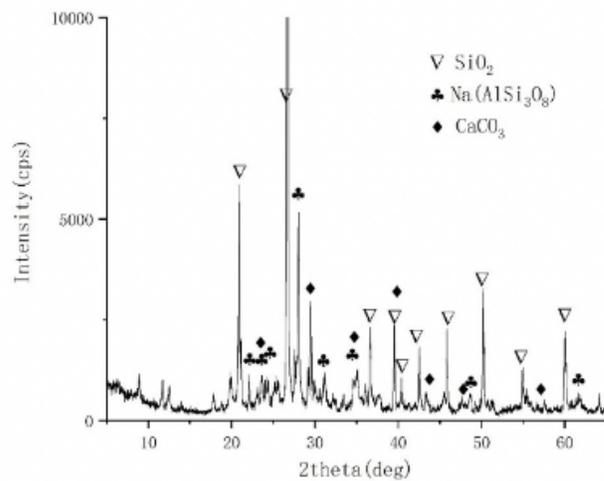
c

Figure 6

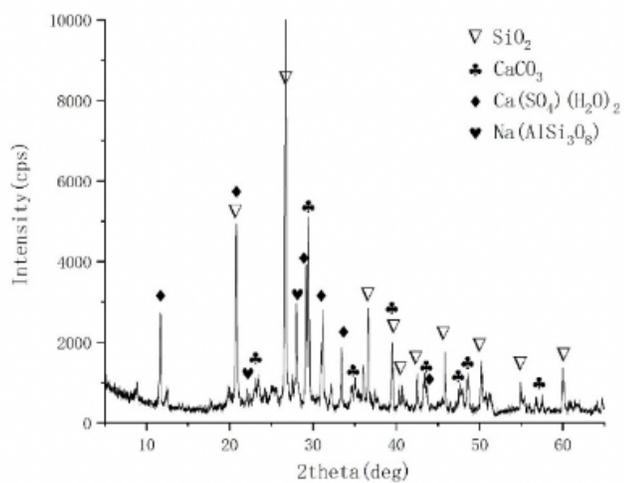
Morphology of paper fibers: (a) JYS-1-1; (b) JYS-2-4; (c) JYS-3-1.



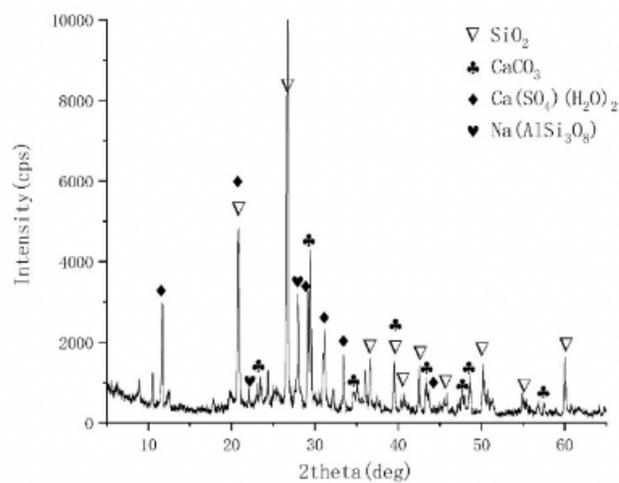
a



b



c



d

Figure 7

XRD Results: (a) JYS-4; (b) JYS-1-5; (c) JYS-2-6; (d) JYS-3-5.