From Earth to Enlightenment
Materiality, Technology and Cultural Transmission of Terracruda Sculpture Across Buddhist Asia
edited by Mònica López-Prat, Emma Cantisani, Susan S. Bean

A Technical Study of *Kneeling Attendant Bodhisattva* from the Mogao Caves, Dunhuang

Construction Materials and Techniques of the Polychromed Air-Dried Clay Sculpture

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Abstract This study of a *Kneeling Attendant Bodhisattva*, a Tang-dynasty polychromed, air-dried clay sculpture from the Mogao Caves, Dunhuang, China, characterises its materials and construction. Removed by Langdon Warner in 1924 for Harvard University's Fogg Art Museum, it remains the only sculpture from the site outside of China. The sculpture has been minimally restored. Examination, imaging, and instrumental analyses reveal that the sculpture was made in situ with traditional techniques of Dunhuang: a bound wooden framework is layered with clay mixtures and decorated with applied details, paint, and gilding. Copper inlays were discovered in the eyes.

Keywords Dunhuang. Mogao. Mogaoku. Sculpture. Langdon Warner. Terra cruda. Clay. Fibres. Air-dried. Polychromy. X-radiography. XRF. SEM-EDS

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Edizioni Ca'Foscari

Marco Polo 6
e-ISSN 2785-5627 | ISSN 2785-5899
ISBN [ebook] 979-12-5742-112-0

Peer review | Open access
Submitted 2026-08-13 | Accepted 2026-10-07 | Published 2026-11-05
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DOI 10.30687/979-12-5742-112-0/004

1 Introduction



Figure 1 (a) Side originally facing the cave entrance, (b) 'Hidden' side facing into the cave niche, (c) Back. *Kneeling Attendant Bodhisattva* (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

1.1 History

Dunhuang, located in present-day Gansu Province, was once a thriving waystation oasis along the travel routes connecting Central and East Asia from the second to the fourteenth century. Located 25 km from Dunhuang, the Mogao Caves (*Mogaoku* 莫高窟 'peerless caves') remain a rich repository of Buddhist culture, preserving textual and visual traditions in its massive cliffside complex of 492 embellished cave shrines. With many cave-shrines decorated corner to corner and including sculptural and wall-painting programs, the visual imagery is distinctly multicultural, reflecting Buddhist and Daoist themes. The spaces were built as sites of familial veneration and Buddhist devotion, constructed primarily by monastics or lay patrons of multiple generations of powerful families. Dating to the early Tang dynasty (618-704), Cave 328 demonstrates the flourishing of Pure Land Buddhism, centred on devotion to the Buddha Amitabha of the Western Pure Land and featured on the transformation tableaux of the north and south walls of the main hall. Consistent with Mogao caves of the early Tang, Cave 328 consists of an anteroom, a corridor, and a square hall with a truncated ceiling depicting the future Buddha Maitreya. Along the west wall, opposite from the hall's entrance from the east, is a recessed niche graced by a total of nine sculptures, one of which was the *Kneeling Attendant Bodhisattva*, originally positioned at the Buddha's proper far right **[figs 1-2]**.

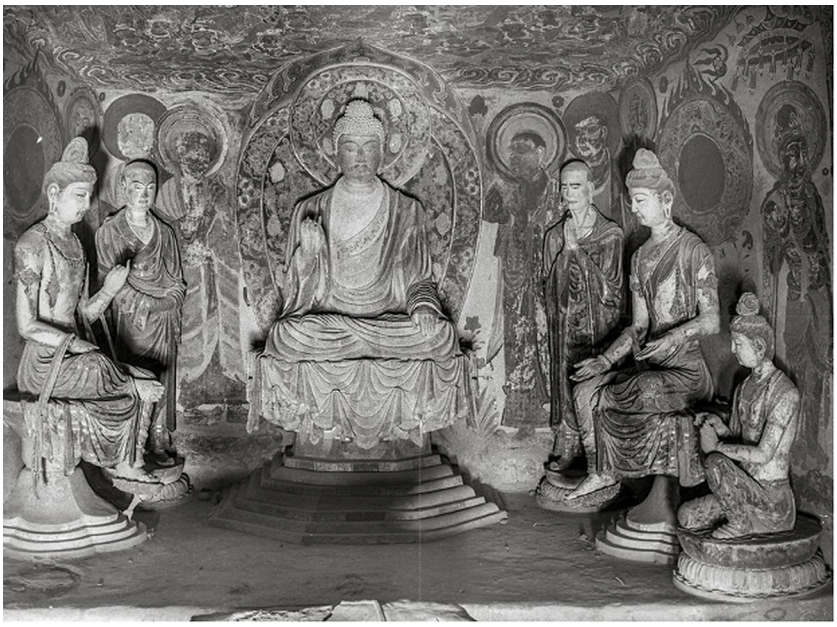


Figure 2 A shallow depression remains where the *Kneeling Attendant Bodhisattva* was positioned. West wall Buddha niche, Mogao Cave 328, Early Tang (618-704). Lo Archive photograph, 1943-44 (Lo 328-2). Lo Archive Images, Princeton, New Jersey, USA. © Trustees of Princeton University

In 1923, American art historian Langdon Warner (1881-1955), the newly appointed curator of East Asian Art at Harvard University's Fogg Museum, led the First Fogg Expedition to China. As the young museum sought to become the first American institutional presence in Asian Art scholarship and collecting, Warner was expected to join the ranks of the archaeologist Aurel Stein and the sinologist Paul Pelliot, who had published reports on the Mogao Caves and dispersed the contents of the Library Cave two decades earlier. In January 1924, Warner removed twelve wall-painting fragments and the *Bodhisattva* sculpture with its base for the Fogg Museum, justifying his actions as an effort to salvage them from further damage caused by the White Russian soldiers **[fig. 3]**.[1]

The fragments and the sculpture arrived at the Fogg in 1924, where they became the subject of scientific study by chemist Rutherford J. Gettens. He analysed the sculpture's pigments and media using optical microscopy and microchemical testing. Although his work remained largely unpublished, it represented pioneering research in the emerging field of conservation science. His notes from 1936 remain in the Harvard Art Museums' conservation records, and he included some findings in his encyclopedia of painting materials (Gettens, Stout 1942).

In 1944, China established the National Dunhuang Art Research Institute (now the Dunhuang Academy), dedicated to research and preservation, emphasizing the study of painting and sculpture through copying images using traditional techniques. Chen Zhixiu is recognised as Dunhuang's first artist to copy sculptures. In 1951, she created scaled-down replicas

1 Warner, *Letter to E.H. Bell* 1924.

of at least five major figures (Du, Du 2025, 7). Generations of artists have since handed down this practice as a critical mode of studying imagery and perpetuating artistic knowledge. Reflecting its cultural significance, the Dunhuang painted sculpture technique received recognition in 2007 as an intangible cultural heritage in Gansu Province (Du, Du 2025, 11).



Figure 3 Langdon Warner, Removal of the *Kneeling Attendant Bodhisattva* statue. January 1924. Black and white photograph. Harvard Fine Arts Library, Special Collections, Cambridge, Massachusetts, USA [public domain]

1.2 Description

The life-sized *Kneeling Attendant Bodhisattva* and its base were constructed *in situ*, measuring 121.9 × 67.3 × 67.3 cm including its base **[fig. 1]**.[2] Free-standing, the figure kneels on the right knee, with the left foot planted on a double lotus base. The *Bodhisattva* leans slightly forward, pressing hands together in a praying gesture. The smooth face has a tranquil, downcast expression, with lips resting closed. Subtle folds modelled on the neck help to emphasise the downward tilt of the head. The ears are elongated, and the hair is styled with a loose, tall topknot. The flesh is painted white with areas of pink shading. The figure is adorned with gilded jewellery, including a long necklace, arm bands, and bracelets. A long scarf is draped over the shoulders, trailing down through the arms. The lower body is dressed in a flowing skirt painted with colourful floral and striped patterns and enhanced with gold details. The skirt has wave-shaped folds that depict a thin, clinging fabric that pools on the top of the base. Painted decoration is executed in a palette of white, red, blue, green, and yellow, with some pink toning and gilded details.

2 Additional information and link to a 3D model can be found on the museum's website: `https://hvrd.art/o/303672`.

1.3 Dunhuang Sculpture-making Process

Since the mid-twentieth century, artists at Dunhuang have developed deep knowledge and insights into traditional materials and painting techniques based on their study and reconstructions of original painted clay sculptures (*caisu* 彩塑). While some modern adaptations appear to have been made for reconstructions, the following summary of the traditional, four-stage process is based on descriptions by Du and Du (2025, 99-136) and Fu (2026, pers. comm.).

1.3.1 Constructing the Core or Armature

Clay mixtures are applied over a core. The type of core depends on the size of the figure. Large-scale figures are formed over stone cores carved during the excavation of the cave. Medium-sized statues, the most common, are modelled over a wooden armature (*mugujia* 木骨架) made with joined timbers or branches. The primary woods used at Dunhuang are the native desert species red willow (*hongli* 红柳; *Tamarix ramosissima*) and Euphrates poplar (*huyang* 胡杨; *Populus euphratica*).

1.3.2 Binding the Straw Core (*caoxin* 草芯)

Organic materials are wrapped around the armature to reinforce the wooden framework, add mass, and reduce the clay's volume and weight. Abundant jiji grass (*jiji cao* 芨芨草; *Neotrinia splendens*) with long, flexible leaves and stalks is used for wrapping and tying; chopped wheat straw (*maijie* 麦秸) has a rough texture that binds the clay mixture; and reeds (*luwei* 芦苇) add bulk.

1.3.3 Modelling

Chengban tu (澄板土) is the alluvial sediment from the Dangquan River at Dunhuang. Often translated as just 'clay' or 'mud', *chengban tu* is the basis for all sculpture and painting at Dunhuang. It is fine-grained and has low shrinkage properties.

- Ground layer (*dizhangceng* 地仗层): A coarse 'straw mud' composed of *chengban tu*, chopped straw, sand, and water is worked into the straw core and built up to model the figure. Du and Du (2025, 112-13) note that since *chengban tu* has poor binding strength, it must have been mixed with a tackier clay, *niantu* (黏土), to hold to the straw-wrapped core. Though yet unproven, they hypothesise that a source of excavated *niantu* for the caves was located 15 km from Mogao.
- Fine layer: 'Fine mud' (*xini* 细泥) or 'hemp mud' made from c*hengban tu* mixed with sand, water, and beaten hemp fibres, is used to model or mould fine details, and to make a smooth surface for painting the sculpture. Other additives may include grass, cotton, rice water, animal glue, or egg whites. As the sculpture slowly dries, shrinkage cracks are filled and smoothed in multiple cycles.

1.3.4 Painting and Gilding

An alum and animal glue solution may be applied to seal the dried clay and improve its water resistance. A ground layer is applied before painting and gilding. Mineral and organic pigments in an animal glue binder[3] are applied.

1.4 Objectives

Today, the *Kneeling Attendant Bodhisattva* remains the only work of its kind outside of China. Despite its long history at the Harvard Art Museums, it has never been the subject of a dedicated technical publication. Aligning with the Dunhuang Academy's commitment to sustaining artistic traditions, this technical study aims to support heritage preservation by advancing understanding of materials and technologies. In turn, this understanding can be applied to planning care and conservation interventions. The study has three objectives:

- Document the condition and condition history of the sculpture, originally intended to be immovable;
- Interpret analysis of the air-dried clay mixtures and fibres, comparing data with existing literature;
- Characterise the construction and modelling techniques, relating observations from visual examination and imaging to published descriptions of sculpture-making.

This paper focuses on the sculpture's condition, the clay mixture's composition, and its construction. A forthcoming paper will address the analytical findings on the grounds, pigments, gilding, and chemical alterations in pigments that have changed their appearance.

1.5 Previous Studies

Previous research on the materials and techniques at Dunhuang has favoured wall paintings over sculpture, reflecting the site's traditional hierarchies and the focus on murals more globally. Despite their technological overlap, references for sculpture remain scarce, particularly in English. This study draws from several publications for terminology, materials, and construction techniques.

For general classification, López-Prat et al. (2024) advocate for the term 'monumental terracruda sculpture' to describe earthen-based sculptures made with shared artistic traditions transmitted via the Silk Roads. Bean (2026) suggests the direct descriptor 'air-dried' for terracruda clay mixtures, rather than misleading words such as 'unfired' or 'sunbaked'.

On earlier sculpture-making practiced in Central Asia, Afghanistan, and India, Tarzi (1986) and Varma (1987) document related modelling techniques for clay and stucco sculptures. For technical execution, Du and Du (2025, in Chinese) offer a contemporary primary source on Dunhuang sculpture-making that combines the perspectives of a master craftsman and a scholar.

3 Researchers at the Dunhuang Academy identified oxhide glue binder on murals through analysis. Plant glues, including peach gum, were also available (Du, Du 2025, 170).

Invaluable to this study, they detail the sources, preparation, and application of traditional materials. Importantly, they document terminology specific to the local materials and processes. Many publications on materials research for Dunhuang wall painting techniques exist; Wong, Agnew 2013 and Su 2021 were the English-language references consulted here.

Historical context is drawn from archival sources and from Bewer 2010, which chronicles the emergence of the conservation profession in the United States, linked with and fueled by the First Fogg Expedition. Balachandran (2007) examines the expedition's preservation ethics and provides the first published descriptions of the damaged sculpture and wall painting fragments.

2 Examination and Analytical Methods

Multiple analytical methods were employed to examine and characterise the sculpture's original materials and alterations. Analysis initially focused on non-destructive methods, followed by limited sampling for further analysis. All techniques were carried out by the authors at the Harvard Art Museums, except where noted.

2.1 Ultraviolet-induced Visible Fluorescence Photography

Materials or conditions that fluoresce in the visible light range (400-780 nm) when illuminated by UV light (typically 315-400 nm) can be identified or distinguished. These include some pigments, binding media, coatings, and restoration materials.

UV-induced visible fluorescence images were captured with a Canon EOS 5D Mark IV camera fit with Peca 918 and Kodak Wratten 2E filters and using TripleBright 3 lights, model LW370-FL68 (370 nm).

2.2 Computed Radiography (CR)

Two-dimensional X-radiographs were taken to examine the internal structure, materials, repairs, and condition. The different radiodensities of materials result in value contrasts in the images.

The X-ray source was an XRS Comet system with MXR-320/26 X-ray tube. Images were captured on a Carestream INDUSTREX XL blue digital imaging plate processed with a Carestream INDUSTREX HPX-1 digital system. The X-ray tube was set with a 3.0 mm focal spot size, using a 3 mm copper tube filter. Exposures were taken at 320 kV, 4.65 mA, 125-270 seconds, with a 250 cm tube-CR plate distance. Images were enhanced with filters applied in INDUSTREX software.

2.3 X-Ray Fluorescence Spectroscopy (XRF)

XRF analysis is a non-destructive, elemental technique that can identify the inorganic elements present on the surface of a sample site. The XRF system employed was a lab-based Bruker Artax XRF spectrometer with a Silicon Drift Detector (SDD) and a rhodium anode X-ray tube. The primary X-ray

beam was collimated to give a spot size of 0.65 mm. Using the Bruker Artax (version 7.6) software, spectra were acquired for 100 seconds live time at 50 kV and 600 µA. Analysis was undertaken without a helium flux, resulting in poor detection of light elements (atomic number of potassium and lower).

2.4 Scanning Electron Microscope with Energy Dispersive Microanalysis (SEM-EDS)

SEM imaging and elemental analysis were used on cross-sections of clay samples to reveal their micro-structure and the elemental composition of different particles and layers.

SEM-EDS was carried out by the authors at the Museum of Fine Arts, Boston. Samples were analysed using a JEOL JSM-IT500LV SEM (tungsten filament) with an Oxford Instruments X-MaxN SDD, 80 mm^2 detector (resolution Mn Kα, 126 eV) running the Oxford Instruments Aztec software (version 4.2 SP1). The SEM was operated in low vacuum mode at a chamber pressure of 60 Pa, with an operating voltage of 20 kV, beam current optimised for dead time of analysis and working distance of 10 mm. The cross-sections were not carbon coated prior to analysis.

2.5 Polarised Light Microscopy (PLM)

PLM uses high magnification and filters to examine samples in detail. This technique was used to study fibre morphology to aid in the identification of the incorporated plant material.

To prepare fibre samples for PLM a sample was covered with a drop of deionised water. The individual fibres were manually separated using tungsten needles under a microscope and then covered using a cover slip. The prepared sample was observed using a Leica DMRX microscope equipped with four objectives (10×, 20×, 40× and 63×). The fibrillar orientation of the fibre was studied using the Herzog test. Images were captured using a Zeiss Axiocam 305 Colour digital camera using the Zeiss Zen 2.6 (blue edition) software. The water was allowed to evaporate before the introduction of the Graff 'C' stain, and the sample was observed for colour changes and images taken as previously described.

3 Materials

3.1 Clay

Clay samples from the *Bodhisattva* were examined with SEM-EDS, revealing a mixture of platy alumino-silicate minerals surrounding inclusions of quartz, feldspar, lesser amounts of calcite, and rare dolomite. The compositions of the platy minerals measured by SEM-EDS are consistent with those of illite (a sheet silicate primarily containing potassium, aluminum, and silicon) and chlorite (a sheet silicate with iron, magnesium, aluminum, and silicon). An alternative technique such as X-ray diffraction (XRD) would be required to confirm the exact clay minerals and/or micas present. All samples were too

small for conventional XRD analysis and would require use of synchrotron XRD (which was not explored in this study). The size of the quartz and feldspar inclusions is highly variable, with larger grains (up to 200 µm) in samples from applied elements. However, the available samples were too small to ascertain the stratigraphy.

Studies of Dunhuang wall paintings have found that the cave walls were prepared for painting by applying a layer of coarse earthen plaster to the walls, followed by a finer plaster layer (Wong, Agnew 2013, 156-61). The primary component of these "earthen plasters" was the local alluvial sediments (*chengban tu*) mixed with sand and vegetable fibres. Analysis of the river sediments shows this is composed mainly of illite and chlorite, with a small proportion of a mixed illite-smectite mineral formed by alteration of illite (Wong, Agnew 2013, 157-60, 266-8). Analysis of the earthen plaster of the cave walls has identified inclusions of quartz, calcite and feldspar, with some dolomite (Dai et al. 2025, 6). This mixture – platy clay minerals around inclusions of quartz, feldspar, calcite and dolomite – is very similar to that identified here from the terracruda of the *Bodhisattva*. This suggests that similar mixtures of river sediments and sands were used for construction of statues and applied to cave walls before painting. This is consistent with Du and Du's discussion of manufacture of sculpture at Dunhuang, using local river sediments mixed with sand and other additives (2025, 111-14).

The use of alum (potassium aluminum sulfate) and animal glue has been described to seal the surface of the fine clay before applying the ground and paint layers (Du, Du 2025, 116-7, 159; Su 2021, 256).

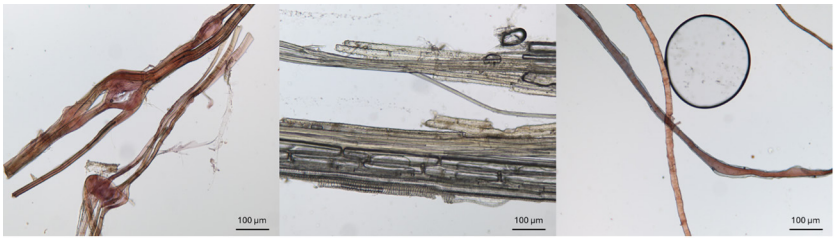


Figure 4 Fibre samples stained with Graff C and viewed in polarised light of (a) twine made from bast, (b) coarse straw fibres in lower clay, (c) fine individual fibres in upper clay. Kneeling Attendant Bodhisattva (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

3.2 Fibres

Polarised light microscopy (PLM) was used to characterise different fibres, including reed-like fibres wrapped with minimally processed bast fibres in the scarf armature. Here, the lower clay layer contains coarse straw, whilst the upper clay layer contains finer, individual bast fibres **[fig. 4]**. Wong and Agnew identified beaten hemp in fine clay layers of wall paintings (2013, 160). Its use cannot be ruled out here; however, PLM of the fibres in the finer clay revealed that many were covered with a membrane, a feature not typically associated with hemp. Analysis of manuscripts found within the Library Cave at Dunhuang identified papers made from varying mixtures of ramie, hemp and paper mulberry indicating that other fibres may have been available (Helman-Ważny 2016). Paper mulberry is well-known for the presence of an

outer membrane on individual fibres and could be a potential match for the fibres observed here, although further investigation is required of the fibre samples and available fibre sources when the *Bodhisattva* was created.

4 Construction

X-radiography revealed the form of the wooden framework, as well as some damage and repairs **[figs 5c, 6a]**. Organic materials with lower densities than the wood could not be resolved at the settings used to penetrate the sculpture's thick clay mass (320kV, 4.65mA, see 2.2).



Figure 5 (a) Visible light, (b) UV light, (c) X-radiograph, *Kneeling Attendant Bodhisattva* (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

4.1 Wooden framework

The wooden armature is constructed with a central vertical timber shaped to support the primary sections of the body. The timber is narrower in the head and neck and cut deeper in the head **[fig. 6a]**. The timber widens towards the base, where a short section is visible.[4] Attached at shoulder height, a horizontal element forms a T-shape (the hands obscure a view of its attachment). Pieces of wood or branches lashed at the shoulders support the arms. Du and Du noted that such joints are typically bound using hemp rope or reeds (2025, 131). A piece of tapered wood extends from each elbow to the centre of the palm, where they appear to join, possibly in a knot **[fig. 7a]**. No additional structure is visible within the hands, though Du and Du (2025, 119-20, 132) note that hands and fingers typically require armatures, such as a small wooden board and bent twigs or reeds, to support the precise gesture and details.

4 Warner (1926a, 31) observed the post extending about eight inches from the bottom of the figure to insert into the base, though it appears shorter in the X-radiograph.



Figure 6 (a) X-radiograph of the head and neck, side view, (b) detail of the inlaid copper eyes with top edge visible, (c) X-radiograph front view, detail showing the inlays' lens shape and position. *Kneeling Attendant Bodhisattva* (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

Supports for the legs appear to attach directly to the central post. The left leg has two pieces of wood bound together at the knee **[fig. 7b]**. The right leg has a single piece of wood inside.

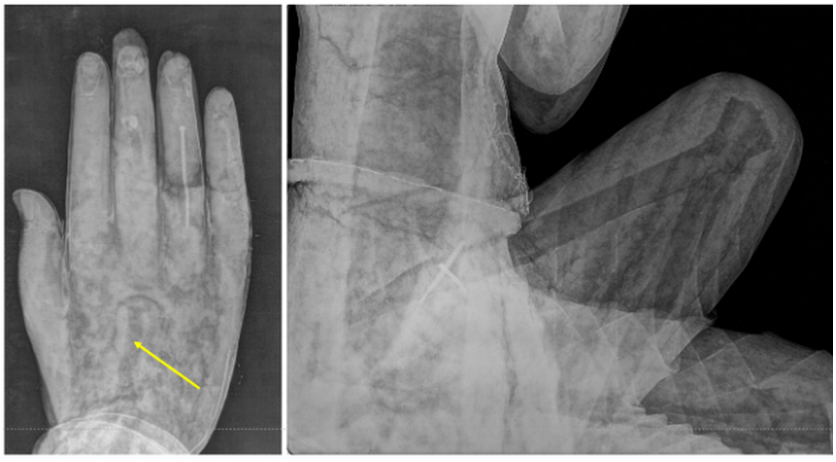


Figure 7 X-radiographs of (a) hands with armature (yellow arrow) in the palm and modern nail repair in the proper left third finger, (b) lower torso and legs showing lashed armature in the left leg. *Kneeling Attendant Bodhisattva* (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

4.2 Modelling

The body is modelled with smooth, rounded contours characteristic of Dunhuang sculpture: the torso and arms are simply formed, and the face and hands are shaped with subtle details. By contrast, the added details depicting the drapery, hair, and ornaments are more loosely modelled, appearing more expressive.

4.2.1 Drapery

The drapery style on the *Bodhisattva* exhibits what Du and Du call 'wave-style' folds, made with applied rolled strips of clay, flattened on one side and attached **[fig. 8]**. Slopes of clay are formed on either side of the strip. In some fragments, incised guidelines for the strips are visible on the underlying clay **[fig. 10b]**. Du and Du (2025, 138, 190-4) indicate that some strips are reinforced with an internal string or cord, though neither was observed. The undersides of the pooled drapery fragments show a straw-bulked clay layer under the drapery **[fig. 10c]**.



Figure 8 Drapery technique (a) left back side of skirt, (b) right leg. *Kneeling Attendant Bodhisattva* (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

4.2.2 Hair

The bulk of the hair is comprised of the coarse clay mixture. This clay is visible through small holes between the tiers, which appear to have been locations where a crown ornament (likely metal,[5] missing before 1924 removal from the cave) was attached. The top knot was formed separately and attached (and reattached in 1924-25). An X-radiograph shows a shallow

5 In Cave 328, the author observed intact, full or partial metal crowns on two other *Bodhisattva*s in the figural group.

void in the head under the knot, which is not understood **[fig. 6a]**. Finished with the fine clay mixture, the hair was textured with loose, incised lines suggesting strands.

4.2.3 Applied elements

Elements formed separately and attached include the scarf, belt, lotus petals, and jewellery. The scarf was made from coarse clay mixed with straw, layered with fine clay, shaped into a long, flat sheet. In front of each upper arm, the scarf floats down unsupported, except for a thin wood prop extending from each hip. The floating portions have an internal support comprised of thin bundles of reed-like fibres wrapped with a Z-twisted twine (identified as bast fibres, fig. 4a), visible at losses.

The belt was formed as a long, rolled coil of fine clay applied to the waist. Deep incised lines form a wavy pattern resembling rope or twisted cloth. Nubs of displaced clay along the lines and clear fingerprints indicate that the clay was quite soft when handled.

The lotus petals were likely modelled from a trimmed slab or cast in a mould and finished with incised lines. One petal appears to have a fibrous internal support along its central axis (visible at a loss).

The necklaces, bracelets, and arm bands appear to have been cast in press moulds, applied, and leaf-gilded **[figs 9c-d]**.[6] Their repeating forms and flat backs, sometimes poorly attached, indicate the use of an open mould. It is not clear if the plain bracelets were moulded. Edges of gold leaf are visible, sometimes overlapping the surrounding area. On the left arm band, gilding stops partway around, where it would be hidden from view.



Figure 9 Gilded, moulded jewellery details: (a) scarf, (b) belt, (c) bracelet on right wrist, (d) necklace pendant. *Kneeling Attendant Bodhisattva* (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

6 Clay press moulds with hemp fibres were excavated in 1965 at Dunhuang. The pattern resembles the armlets in Cave 328 (Du, Du 2025, 149).

4.2.4 Eyes

The eyes are inlaid with thin copper sheets depicting the iris and pupil together **[fig. 6]**. The metal surfaces appear black with a slight sheen. The edge of the right inlay is visible under the upper right eyelid **[fig. 6b]**. X-radiographs show that the inlays have a concave, lens shape, though with the top edge cut straight, aligning with the upper eyelid **[fig. 6c]**. The sheets appear to be set onto elliptical forms incorporated into the face as it was modelled. *In-situ* XRF analysis identified copper metal. There is no evidence of restoration around the inlay.

5 Condition

The sculpture remains in fragile, though remarkably well-preserved, condition, considering the brittle medium, its weight (88 kg, including the replacement base), and the removal and transit it endured.

5.1 Condition history

Of the nine sculptures in Cave 328, Warner selected the *Bodhisattva* for its well-preserved condition.[7] Damages visible in the 1924 image after its removal from the cave include cracks in the scarf, a lost crown ornament and a section of the necklace, drips beneath the forearms, and uneven, darkened areas on the white-painted skin **[fig. 3]**. Most or all the lotus petals on the base appear intact.

Repairs at the Fogg Art Museum are sparsely documented,[8] though brief mentions in correspondence and evidence of repairs make it clear that structural repairs undertaken after its arrival addressed damage sustained during the sculpture's transit. They included replacing the lotus base with a wood-and-plaster structure and reattaching only sixteen original petals. Several elements were reattached (the top knot, arms, wrists, fingers, and parts of the scarf) using an opaque, light-brown adhesive, identified as animal glue by its solubility in water.[9] Under ultraviolet (UV) light, this glue fluoresces bluish-white **[fig. 5b]**. The bright, yellow-white UV-induced fluorescence corresponds to the lead-white-painted skin and/or lead-white-containing ground, rather than to a restoration material. Cellulose nitrate, a 20th-century adhesive, was detected in numerous paint samples (both in 1936 by Gettens and in this study), suggesting it was applied to consolidate flaking paint.

In 2015, eleven disassociated painted and gilded clay fragments found in a Harvard Art Museums' storage room were identified as original sections of the skirt that pool on the base **[fig. 10]**. Although Warner no doubt collected them, they are not visible in the 1924 image, the museum's early photographs,

7 Warner *Letter to E.H. Bell* 1924.

8 Forbes *Letter to L. Warner* 1924, briefly described work done by John Evans & Co., Boston: replacing the 'pedestal' and gluing the sculpture to it. His description of the internal structure of an arm indicates it was detached. Also, Forbes, *Letter to L. Warner* 1925, referred to Arthur Pope (Harvard Prof. of Fine Arts) "gluing on the remaining pieces" of the sculpture.

9 2015 Harvard Art Museums conservation treatment report by Anthony Sigel.

or descriptions. Notably, the comparable elements on other figures in the cave are unpainted, appearing as plain clay in low relief **[fig. 2]**.[10]



Figure 10 (a) 'Pooled' drapery on base with painted and gilded decoration, (b) fragment with detached fold and incised guidelines, (c) back of fragment showing coarse clay bulked with straw. *Kneeling Attendant Bodhisattva* (from Mogao Cave 328, Dunhuang, Gansu province). Late-7th c. Air-dried clay with paint and gilding, 121.9 × 67.3 × 67.3 cm. Harvard Art Museums/Arthur M. Sackler Museum, First Fogg Expedition to China (1923-24), 1924.70. Cambridge, MA, USA, © President and Fellows of Harvard College

5.2 Current condition

While earlier repairs seem stable, compound breaks or cracks have occurred in other inherently weak areas of the construction: the neck, where the clay is especially thin and bears the weight of the head **[fig. 6a]**, and around the waist below the belt, where the top-heavy torso meets the stable lower body. Along horizontal cracks, some areas have settled and become misaligned, disrupting the paint and fine clay. Additionally, repaired breaks across the upper arms correspond with the area just below the crossmember of the armature where the heavy arms angle forward and extend from the torso, unsupported **[fig. 5c]**. At these inherently weak areas, it is assumed that the object's transit and time have exacerbated their severity.

There is little to no observed retouching of the painted surface. The darkened white skin tones, observed by Warner in 1924, appear unchanged in severity or spread. It appears on the figure's facets facing the cave opening. Notably, the other figures in the cave exhibit the same effect on their respective presentation sides.

6 Discussion

The wooden armature, clay mixtures, fibres, and construction techniques identified in the *Kneeling Attendant Bodhisattva* align with Dunhuang traditions as documented by artists and researchers.

The term "monumental terracruda sculpture" is apt: it underscores the figure's original (and now lost) cave-shrine context while describing its air-dried clay composition and structure. The fine execution of modelling and techniques for applied elements further demonstrate the artist's (or

10 As observed by the author on site.

artists') versatility. While intended as an immovable work, the sculpture's intact, yet fragile, condition after removal reflects its skilled construction. X-radiographs show the configuration of the robust wooden armature that continues to hold the surrounding brittle, heavy clay layers. Furthermore, the images highlight the structural balance of the leaning posture with unsupported, 'floating' arms. Despite historical repairs, the sculpture's inherently fragile areas now require intervention to stabilise cracks. This understanding of the sculpture's materials and condition can now inform conservation treatment planning.

The characterisation of materials shows that the clay composition and stratigraphy over the bound wooden armature are comparable to those of Dunhuang wall paintings on the conglomerate rock wall of the caves. Both have layers based on local *chengban tu:* a coarse layer (*dizhang*) mixed with straw, other fibres, and sand, followed by a finer (*xini*) clay with finer fibres. For the wall paintings, these layers are sometimes called earthen "plasters" (Wong, Agnew 2013, 156-60). For sculpture, Du and Du noted the additional need for another tackier clay, *niantu*, which can bind the coarse layer to the straw-wrapped core (2025, 112-3). In the absence of reference samples, it is not possible to confirm the presence of two types of clay.

The discovery of copper-inlaid eyes is notable and without known parallel at Dunhuang. However, earlier and contemporary lacquer sculptures, dating from the late sixth to the seventh century, from China, have documented examples with inlaid black and dark green glass eyes (Strahan 2023, 28). Du and Du (2025, 155) note that Dunhuang sculptures typically feature painted eyes, though some Qing Dynasty figures have inlaid porcelain or glass beads. On this *Bodhisattva*, the copper inlays are difficult to discern, appearing dull black in the shadow of the eyelids. It is unclear if this dark appearance resulted from intentional colouration or natural oxidation, which occurs quickly on copper. Because the visual effect is so subtle, similar inlays may have gone unnoticed on other sculptures at Dunhuang. However, the metal crowns decorating other *Bodhisattva*s in Cave 328 confirm the use of metal components with the clay sculptures. Beyond their aesthetic function, the inlays may have been added for ritual purposes or iconographic significance.

Although visual examination and X-radiography revealed the general structure of the wooden armature, 2D X-radiography presented limitations due to the object's bulk and density. As mentioned, the high energy levels used to penetrate the clay mass could not simultaneously resolve the wood armature and less radio-dense organic components, such as the fibre bundles wrapping the framework. Additionally, overlapping elements and cracks were obscured. A 3D X-ray imaging technique with greater dynamic range, such as computed tomography or other 3D X-ray imaging[11] could better discern internal structures and materials with varying densities. CT scanning was not an option for this study since the available equipment could not accommodate the size of the sculpture.

Imaging and analysis cannot reveal important intangible and time-based aspects of fabrication known to artists copying Dunhuang sculptures. For example, Du and Du (2025, 131) describe the consecration ritual of inscribing the wooden armature with a dedication or sutra before binding and adding clay. Also, the time and labour required for processes such as gathering

11 Such as the technique developed by Bossema et al. (2024).

and preparing materials, drying, and making repairs remain invisible in the finished work and cannot be grasped without practical knowledge. The perspectives of contemporary artists at Dunhuang are therefore invaluable to understanding these essential aspects of the sculpture.

7 Conclusions

This study documents the condition and condition history of the *Kneeling Attendant Bodhisattva*, which suffered structural damage during its 1924 removal from Cave 328 at Dunhuang and subsequent transit to Harvard University. Integrating archival records with visual examination and X-radiography provided a comprehensive assessment of its current fragile condition.

Du and Du's (2025) technical descriptions of Dunhuang sculpture-making proved invaluable for understanding a single work, long separated from its original site. Researchers interested in monumental terracruda sculpture and contemporary Dunhuang sculptors may gain insights from this study, particularly concerning the structure of the wooden armature and the copper inlaid eyes. Analysis of the paint and gilding will be reported in a future publication. Notable findings will include the varied colour techniques and shifts in colours resulting from chemical changes.

Future research could utilise advanced 3D imaging and collaborative consultations with Dunhuang Academy specialists to compare findings across Cave 328's other sculptures and wall paintings, deepening a contextual understanding of the *Bodhisattva* and informing conservation strategies to stabilise the structural cracks.

Acknowledgments

The authors are grateful to the following colleagues for their support and assistance: Francesca Bewer, Joanne Bloom, Susanne Ebbinghaus, Xingbo Fu, Narayan Khandekar, Sarah Laursen, Deborah Mayer, Megan Schwenke, Tony Sigel, Kate Smith, Melanie Volz, and Meimei Xu.

SEM was undertaken at the Museum of Fine Arts Boston, with thanks to Richard Newman.

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