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Tradition Unveiled: Pottery Production in the Brazilian Kadiweu Culture

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Abstracts

The ceramic bowls production of the Brazilian Kadiweu culture (Rio Nabileque, Mato Grosso do Sul), currently belonging to Museo delle Civiltà (MUCIV) – Museo Nazionale Preistorico ed Etnografico "Luigi Pigorini" in Rome, were studied for the first time by a multi-analytical investigation at Istituto Centrale per il Restauro (ICR, Rome). Optical microscopy on thin section (OM) and X-ray Powder Diffraction (XRPD) were used to characterize two Kadiweu bowls (raw materials, firing and production process). UV observation and micro-Fourier Transform Infrared Spectroscopy (μ-FTIR) were used to characterize either original or former restoration products. Finally, X-ray images were taken to study the modelling technique. This minimally invasive approach showed that raw materials and technology are compatible with local production. The use of grog was documented for the paste, which was then fired at moderately high temperatures. This study also led to revise some ethnographic data on decorations, at least for the analysed bowls, such as the use of kaolin as white pigment, which was instead proven to be calcite, or the origin of the traditional black dye from pau santo, a local tree. Its spectrum was for the first time collected on ceramics and identified as guaiac resin, which possibly comes from *Guaiacum sanctum* or *officinale*. This research project also allowed the identification of two different restoration activities, with two types of adhesives: shellac and animal glue, the latter used with lithopone. Paraloid B72 was also identified as a protective layer. Finally, textile materials found on the artefact were also characterized.

Keywords: Brazilian Kadiweu ceramic; Multi-analytical investigation; Guaiac resin; OM; XRPD; μ-FTIR; Restoration products

Introduction

The Kadiweu (from the Guaicurù expression "Eyiguayegui" – literally, people of the Eyiguá palm), or Caduveo, is an indigenous population in Mato Grosso do Sul, that inhabits from the 19th century the area Serra da Bodoquena, close to the basin of the River Nabileque.

Information is scarce about their ceramic production before colonialism. However, archaeologists have recently unearthed several ceramic shards at Fazenda Caiman, Porto Murtinho, which they describe as belonging to the Pantanal Phase (2800 – 1700 BC) [1]. These shards exhibit cord-marked incisions and coloured decorations being considered as ancestral models of Kadiweu ceramics. Modelling and firing techniques are indeed believed to come from the Guaná, a sedentary population with a certain knowledge of agriculture and fictile objects production settled in northern Chaco (Amazonian Basin). In Chaco, the Guaná came into contact with the Guaicurú-speaking Mbayá, nomadic hunters, fishermen and warriors, of which the Caduveo formed a part. Ceramic practices hence became popular among the Guaicurú and have been passed down from one generation to another [2]. According to Herberts [3] the same population, which later assumed the name "Kadiweu", specifically started to use ceramics after the 18th century migrations in the Chaquenha region. The area, called Pantanal, was indeed chosen because of its high quality clay [4].

A classification of the Kadiweu houseware was given - according to its function - by the missionary Sanchez-Labrador in 1760 [5]. He had in fact described the presence of food pans (ginogo), liquid-storage jugs (nalima) and ceremonial bowls (mbocayà) typically containing palm-based food [6]. The latter were characterized by a rich decoration on both sides of the bowl. They are told by the photographer, painter and anthropologist Guido Boggiani to be used in rituals of women's initiation.

Boggiani went to visit the Kadiweus twice, in 1892 and 1897. The memories of his experience are collected in the book “Viaggio d’un artista nell’America Meridionale. I Caduvei (Mbayá o Guaicurú)” (1895) [7], where a detailed description of the Kadiweu pottery production is provided. During the time spent there, he also collected several objects as part of his personal ethnographic collection, which was later acquired by Luigi Pigorini in 1894 after extenuating negotiation. The collection now belongs to Museo delle Civiltà (MUCIV) – Museo Nazionale Preistorico ed Etnografico “Luigi Pigorini” in Rome and it includes 2468 pieces.

A multidisciplinary approach was for the time applied to study two Kadiweu bowls in terms of execution technique and previous restoration practices, and thus confirm or compensate ethnographic data. The ethnographic literature concerning the survey and production of the Kadiweu ceramics is exhaustive [7-9], while a scientific characterization has never been carried out. In the last decades, a multi-analytical approach has been efficiently used for deep characterization of ancient pottery [10-14], taking care of their uniqueness by minimum sampling. In this work, UV Fluorescence was performed first, to evaluate the presence of non-original substances (repainting and restoration products) and thus define the best sampling strategy. Optical microscopy (OM) was used to characterize textile materials and, on thin section, to describe the different steps of production (clay paste features and firing). Micro-Fourier-Transform Infrared (μ-FTIR) Spectroscopy was applied on micro-fragments to identify both decoration and restoration products. X-ray Powder Diffraction (XRPD) was used to determine the mineralogical composition of either clay or pigments. Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy (SEM-EDS) was used to confirm the nature of decorative/restoration products. Finally, X-radiography was used to describe thickness, inclusions and joints, to infer on forming practices.

Materials and methods

The Kadiweu bowls

The two Kadiweu bowls were chosen from the collection of MUCIV. These bowls, sold by Guido Boggiani to Luigi Pigorini on the 3rd of October 1894, were catalogued in the Prehistoric and Ethnographic Museum “Pigorini” as 52878 and 54061 (Figure 1). They are both decorated in the traditional way: geometrical impressed design, with red and dark brown pigments. The impressed contours are infilled with a white powder in order to highlight the design. The external rim is adorned with small glass beads, strung onto a thread put through the ceramic by tiny holes.

Figure 1: Kadiweu bowls under investigation: 54061 (left) and 52878 (right).

The large bowls can be both classified as mbocayà, the traditional ceremonial houseware. Of these, bowl 52878 (38.5 cm diameter, 11 cm height) appeared to be preserved for ca. 80% of its original surface, with dust and soot encrustations and partially missing decorations (especially beads). It had undergone previous restoration: in 1894, soon after its inclusion in the Pigorini collection (see the Museum sheet E in [15]), and in the ‘70s. During these restorations, the bowl had been recomposed and pieces stuck together with two different adhesives. Fillings had been done in plaster and local re-paintings had been carried out. Finally, some thread had been employed to recompose bead decorations, sometimes improperly.

Bowl 54061 (32 cm diameter, 10 cm height) lacks restoration documents, but an intervention is stylistically dated to the ‘90s[1], in which the original shape had been recomposed with pigmented plaster fillings. Ca. the 80% of the artwork is preserved.

Sampling and Characterization Techniques

In this study, UV photographs were taken with a standard camera in a dark environment. Subsequently, micro-samples were taken from both bowls and thin sections were prepared to investigate the composition of the ceramic paste and the possible presence of painting layers.

[1]Information about past restorations on both bowls comes from a personal communication by Francesca Quarato, restorer at MUCIV.

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OM was performed using a Leica DM RXP, with a UV fluorescence source (HBO mercury vapor lamp, 50W), in reflection mode. Petrography was also applied to investigate the mineralogical and textural composition of the bowls. Thin sections were analysed under parallel (PPL) and crossed (XPL) polarizing light by a Zeiss Universal microscope to describe inclusions, voids, and matrix. These sections were also analysed by SEM-EDS using a ZEISS EVO 60 equipped with an EDX Oxford Instrument X-Max 50 and INCA X-sight dispersive X-ray spectrometer (EDS Oxford Instruments Detector 7636 Energy). The AZtec 3.3 SP1 software was used to collect and analyse chemical data.

For µ-FTIR spectroscopy a Thermo Scientific Nicolet iN10 MX was used. Spectra were collected in the 4000–675 cm^{-1} range under transmission mode, with 16 scans and 8 cm^{-1} resolution. They were then visualized and processed by OMNIC™ Picta software.

A few mg of bowl 52878 were scratched from fragmented edges and powdered for XRPD. A Bruker D8 (Cu Kα radiation) was used. Data were collected in the 5-65 ° 2θ range with step scan of 10°/5 seconds and a Pilatus 100k-A area detector. Diffractograms were analysed by DIFFRAC.EVA software and the ICDD PDF4 plus reference database was used for phase identification. For X-radiography a W-tube X-ray unit operating at 50 kV and 1 mA was used, with 60-minutes exposure time and at 120 cm source-object distance. Images were stored as 8-bit TIFF files.

Results and Discussion

Characterization of the execution technique

The observation of thin sections showed that grog fragments are common as temper. These inclusions often display remarkable dimensions (up to 3 mm in diameter) and irregular edges (Figure 2a). They also share common features, in terms of inclusions and texture, with the matrix. However, their colour is slightly brighter (pinkish to brown) from the matrix, where a grey colour is predominant under reflected light (Figure 2b). The chemical composition of the grog, as determined by SEM-EDS, is strongly compatible with the matrix: CaO ~ 0.74%, SiO_2 ~ 75.83%, Al_2O_3 ~ 14.88%, K_2O ~ 1.32%, Na_2O ~ 0.45, Fe_2O_3 ~ 4.26%. These data all lead to infer the reuse of similar ceramic shards.

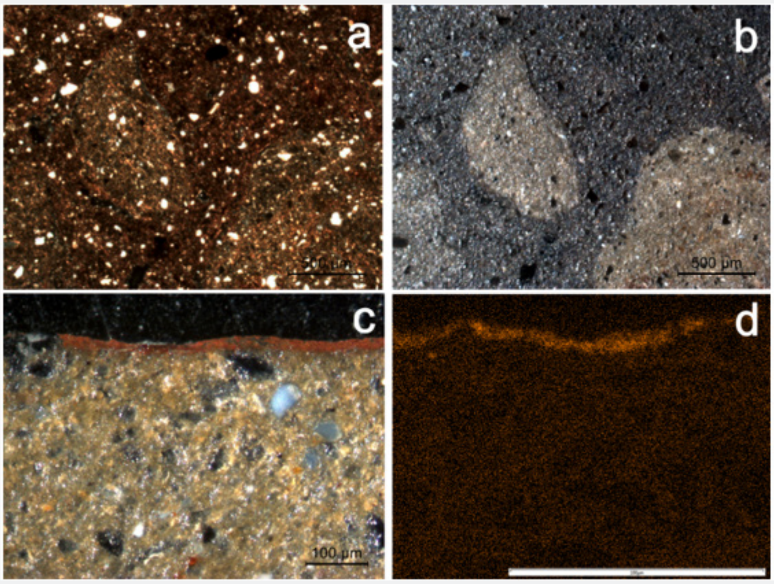

Figure 2: Kadiweu bowl 52878 in thin section: observation at 2.5x under transmitted XPL (a) and reflected visible light (500 µm scale bar in a and b, 100 µm in c); elemental mapping of Fe by SEM-EDS on the same magnified area (100 µm scale bar, d).

According to the most recent bibliography, the use of chamotte - "cacos de cerâmica triturada" - was quite common by the end of the 19th century, as it can be derived from the comparison of Boggiani's [7] and the more recent Levi-Strauss' [8] and Ribeiro's [9] testimonies.

The porosity is mainly from shrinkage, present between grog fragments and matrix, the sandy skeleton is mainly composed of small quartz grains, suggesting the use of a well-refined clay, possibly coinciding with the best quality *ikonopá*[2] collected from nearby streams [16]. In the matrix, rare acicular crystals of muscovite are visible.

XRPD analysis confirmed the predominant presence of quartz, along with minor muscovite (Figure 3). The absence of minerals such as calcite, gehlenite or diopside makes it difficult to infer about the firing temperature. However, SEM analysis showed the absence of vitrification in the matrix, suggesting that the

[2]Kadiweu word for "clay", in Oberg K [16].

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transformation into secondary components did not occur. Hence, we can hypothesize a low firing temperature, which is compatible with an open fire, as first reported by Levi-Strauss [8] and then confirmed for more recent productions by Müller [6] and Perrotti [2].

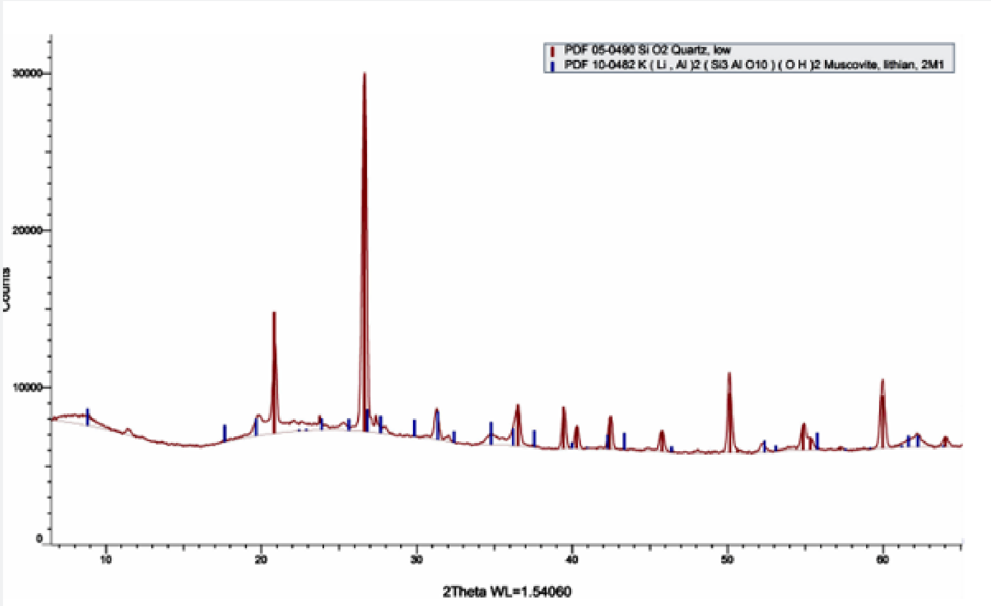

Figure 3: XRPD pattern of bowl 52878, showing predominant quartz (red reflections) and minor muscovite (blue).

The observation of the thin section close to the external surface highlighted the presence of a red ochraceous pigment (hematite), as confirmed by SEM-EDS mapping (Figure 2d), which is indicative of the selective application of a red slip. The white pigment used in cord-marked incisions on bowl 54061 is calcite, as determined by both FTIR and XRPD with traces of quartz in (Figure 4), and no trace of clay minerals.

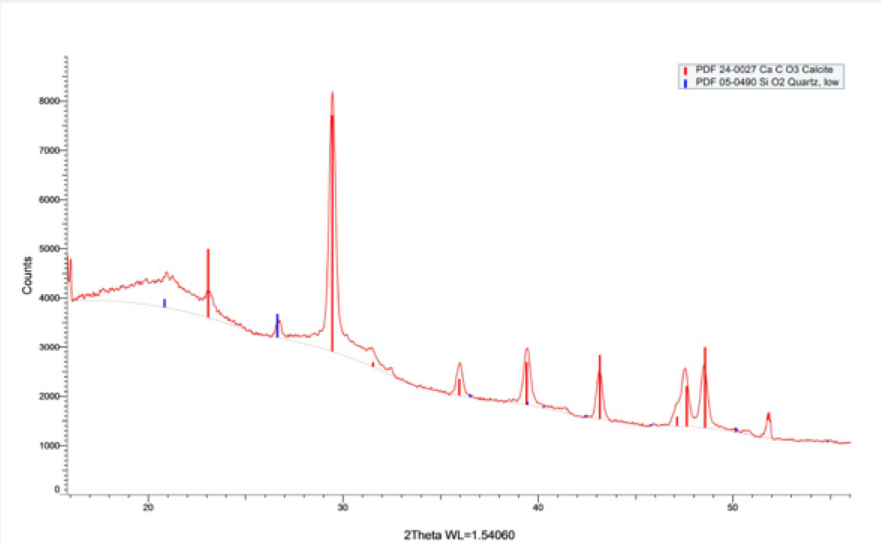

Figure 4: XRPD analysis of the white pigment used on cord-marked incisions, bowl 54061, identified as calcite (red reflections) with small amount of quartz (blue reflections).

The palette hereby characterized for the outer side of the bowls is partially in agreement with previous assumptions. Ochres have been said to be common as pigments in the Kadiweu decorated ceramics, for red depicting, along with kaolin for the white areas

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[2]. Our study proves that what was believed to be kaolin is indeed calcite, at least in the ceremonial bowls investigated in the present study. The presence of abundant calcite had been mentioned in a few analyses carried out by Instituto de Pesquisas Tecnológicas – IPT on local clays used for decoration purposes, but they were described with the generical term “kaolinitic clay” [2].

These thin calcite lines are used together with a dark dye to form geometric decorations on both bowls, as it is well documented for both the Boggiani (Museus of Basel, Switzerland, Museum fur Volkerkunde, Staaliche Museen zu Berlin, Germany, and the MUCIV) and the Ribeiro (Museus Nacional e do Índio, Rio de Janeiro, Brasil) collections. The organic nature of this dark brown pigment was revealed by μ-FTIR analysis, its spectrum showing high compatibility with the one of the so-called “gum guaiac”.

This result partially agrees with ethnographic reports, which suggested the use of the resin from a local tree in these typical dark brown decorations. They refer to this tree with its vulgar name “pau santo” [2,4,17]. Indeed, this epithet is commonly attributed to a series of plant species, including *Kielmeyera coriacea* and *Guaiacum sanctum or officinale* [18]. Of these, the first has been described as the source of the black resinous pigment by Perrotti [2], despite there is no scientific evidence that gum guaiac comes from this tree [19]. On the contrary, the resin from *Guaiacum sanctum* has been described to contain alpha-guaiaconic acid (or furoguaiacin) [20], which is responsible for most of the signals in our spectrum (Figure 5), as first identified by Kratochvil [21] for alpha-guaiaconic acid extracted from *Guaiucum sanctum L.* or *G. officinale L.*

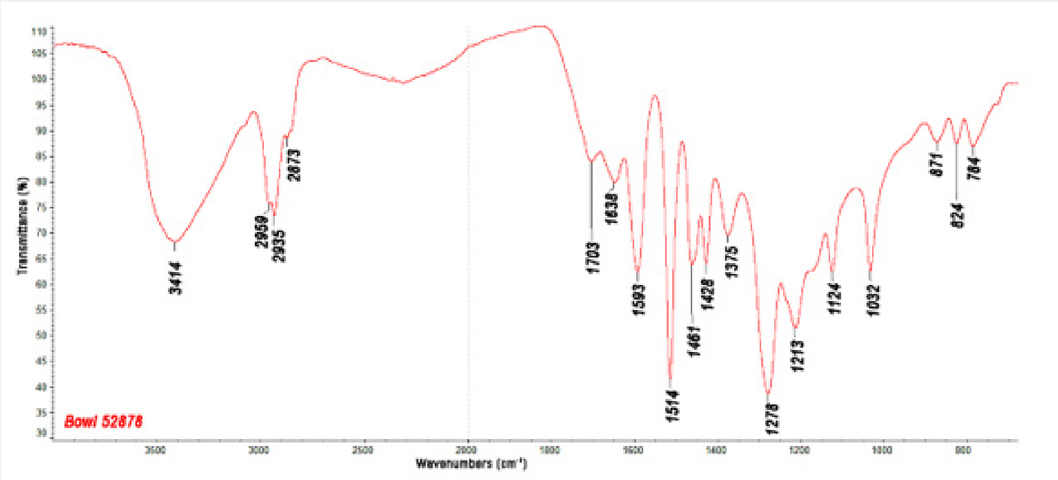

Figure 5: FTIR spectrum of the dark pigment used on bowl 54061.

This resin is particularly perishable and in fact appeared variously altered on the analysed bowls, especially in 54061, where it displayed fading, cracking and partial loss.

According to macroscopic observation, the red ochraceous pigment was applied first and then followed by the dark dye, while the white pigment was finally used to fill previously made incisions. The colouring sequence is in accordance with ethnographic references [16]: it is in fact reported that hematite was powdered and used before firing; the dark dye from *pau santo* was indeed applied soon after firing while the white “clay” on the cooled manufact.

No other hues were identified in the analysed bowls. This finding is compatible with what documented for the less recent Kadiweu production, even for the most archaic production of the Pantanal Phase [1]. On the contrary, the most recent ceramics, as documented by Romizi [22] and also shown in the Plínio Ayrosa collection (Coleção do Museu de Arqueologia e Etnologia, MAE of Universidade de São Paulo, Brazil) dated 1987, have greater variability in colours, which includes pink and green hues due to the wise mixing of the raw materials identified in this study [2].

The thread used for bead ornaments, was also analysed. Microscopic investigation (Figure 6, left) led to the characterization of the original two-ply cotton yarn with S low twist. Each ply is Z-twisted.

The use of cotton for bead yarns is compatible with the intense cultivation and use of this fibre among the Kadiweus, either for textile or houseware objects, which was already disappearing at Boggiani’s time [22] and no more active at Ribeiro’s time, in the mid-20th century [2]. The modelling technique could be derived from X-ray images (Figure 7).

They document that the base had been formed from a hand-modelled disk, probably pressed in a mold, to which two or three coils had been later applied to have big bowls. The use of a mould is indeed testified by the uneven thickness of the base – see black and light gray areas, corresponding to different hand pressures

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in association to rotation in Figure 7a. The coiling technique documented both for the less recent [5,7,16] and modern Kadiweu productions [2], can be recognized in bowl 54061 from the same preferential arrangement of pore space (concentric lines in the projected X-Ray image) and a few larger elongated vesicles occurring at the junction between coils (Figure 7c). Anyway, the final burnishing of the inner surface of the bowl made the modeling traces less visible.

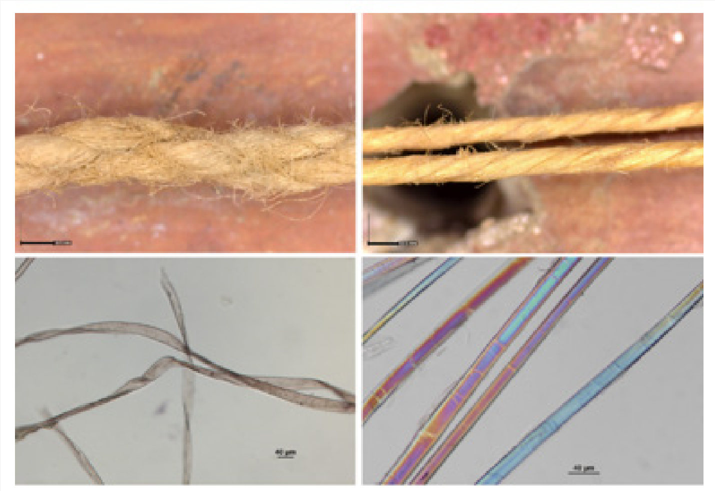

Figure 6: Types of yarn in bowl 52878 observed under OM: original cotton (left) and restoration linen (right) thread, reflected (top, scale bar 0.5 mm) and transmitted light (bottom, scale bar 40 μm).

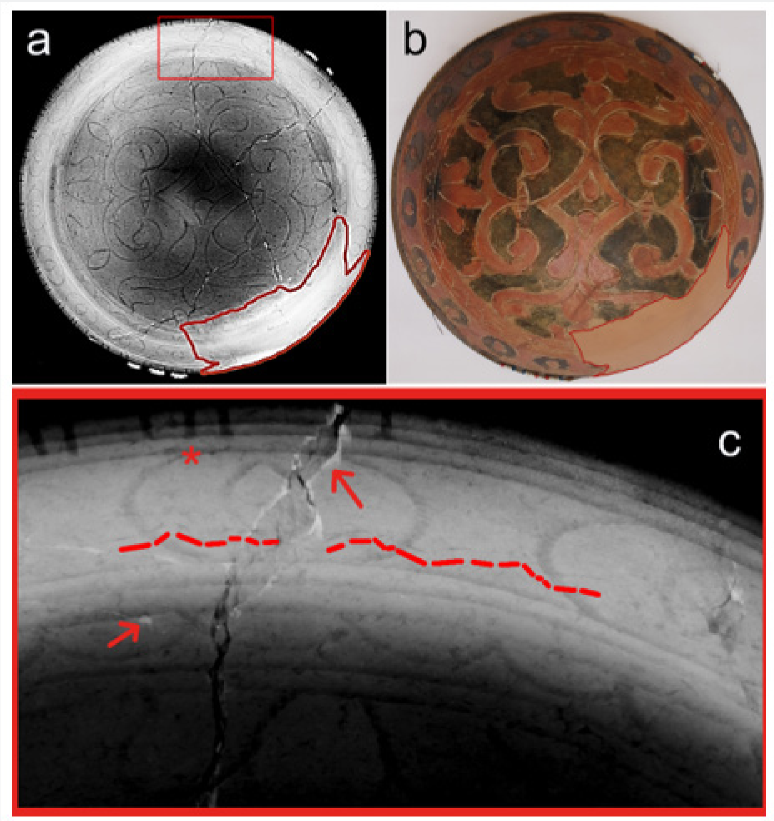

Figure 7: Enhanced radiograph of catalogued bowl 54061 (a) and the corresponding visible image (b), where a plaster-filled area is marked in red; magnified view of the top border in X-ray (c), where the following marks are used: red asterisk for the irregular sequence of beading holes, red arrows for lithopone traces and a dotted line for the typical, elongated vesicles due to coiling.

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Hole pairs for the beading, surely made in the clay at its plastic state with a sharp tool, are quite regular. The only exception is the ending one, visible in a line of three holes, instead of two (see the asterisk in Figure 7c). The third hole can be seen only in the X-Ray image since it was sealed with stucco after firing.

Past restoration products

A different type of yarn has been used for the restoration (undated) of lost bead ornaments. It consists of a three-ply linen yarn, S-twisted, as defined by OM (Figure 4, right). Sometimes, these restored ornaments exhibit misplacement.

UV fluorescence allowed the identification of several restoration products. Especially in the concavities of the cord-marked incisions and on superficial areas, a pale yellowish fluorescence was documented (Figure 6). A micro-sample from one of the areas showing this typical fluorescence was taken and its analysis by FTIR led to the identification of Paraloid B72, an acrylic resin possibly used as protective agent in a previous restoration, on both sides of the bowl.

A strongly different fluorescence – bright orange – was reported in some junctions between fragments, which was later identified as shellac by μ-FTIR, employed as restoration adhesive (Figure 8b). In other junctions and superficial areas, the fluorescence was indeed pale bluish, suggesting the use of a different kind of adhesive, made of animal glue and saponified oil (Figure 8c). The analysis of a micro-fragment of this latter adhesive by SEM-EDS let us infer that oil was applied later than glue. Oil was in fact present on the ceramic surface along with some chemical elements such as P, Zn and Ba. Of these, phosphorous is widespread as grains on the mapping of the analysed fragment and possibly comes from the use of casein or animal glue and bone residues. On the contrary, zinc and barium are attributed to the modern pigment lithopone. The presence of barium can be also confirmed by the thin, bright stucco fillings in the X-ray image see (Figure 7, arrows in the magnified area). The presence of two different adhesive products might be explained by two different, not simultaneous, restoration activities, whether it is not possible to discern about their timing. However, we can almost surely exclude a restoration in Brazil, meaning the artefacts, when acquired by Boggiani, were damaged.

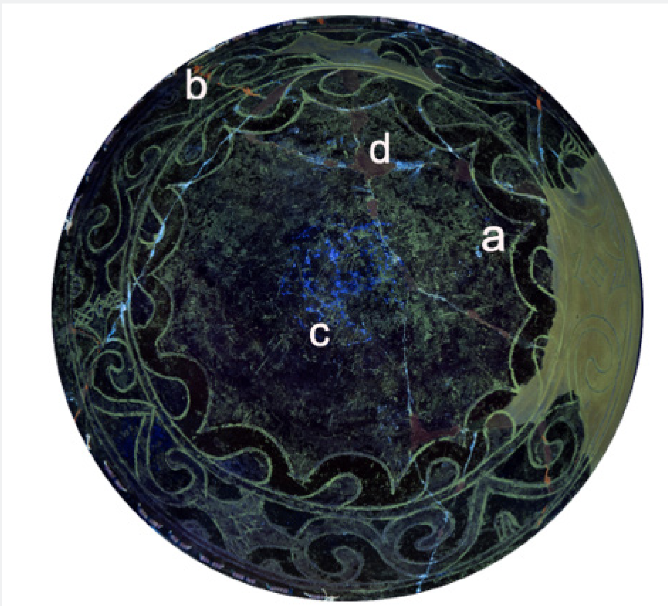

Figure 8: Types of restoration products recognized by UV fluorescence in the Kadiweu bowls: (a) pale yellowish, Paraloid B72; (b) bright orange, shellac; (c) pale bluish, glue with saponified oil; (d) pale red, pigment for retouching.

Finally, UV fluorescence also allowed the recognition of a dark brown pigment used for retouching (Figure 6d), which shows distinct features from the original guaiac resin.

Conclusion

Two Kadiweu bowls were analysed for the first time in the present work. A multi-analytical approach with minimum invasiveness was used to gain information on the nature of both original and restoration products, as well as to shed light on the production steps, from raw materials to firing and finishing.

This study hence stands as one of the few examples of conservation science applied to the study of ethnographic collections, highlighting the fundamental contribution given by a parallel investigation. In the present study, the use of a well-refined clay paste with chamotte and its firing at low temperature

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were assessed. A combined forming technique was characterized, thanks to X-radiography: mould for the base and coils for the walls. The typical palette of Kadiweu ceramics was proven to be made of ochres, gum guaiacum and calcite. Beading was originally realized with a cotton yarn, later restored using linen. Analyses also showed that other restoration products had been applied on the bowls: shellac and animal glue - with lithopone - as adhesives, acrylic resin as protective, and a dark pigment for retouching.

The coupling of μ-FTIR and XRPD led to revise some ethnographic data on Kadiweu pigments. In fact, our study did not confirm the use of kaolin in the white cord-marked incisions. It also attested that the guaiac resin in black decorations more possibly come from *Guaiacum sanctum* or *officinale* and not from *Kielmeyera coriacea* both trees are reported with the vulgar name "pau-santo" in references, but the latter was improperly believed to be the source of the black dye. We possibly suggest a further characterization of this resin by chromatographic analysis, to confirm its provenance.

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Authorship Contribution Statement

Michela Botticelli: Data curation, Investigation, Writing - Original Draft. Valeria Bellagamba: Investigation, Writing - Original Draft. Roberta Bollati: Conceptualization, Supervision, Writing - review & editing. Lucia Conti: Formal analysis, Writing - review & editing. Giancarlo Sidoti: Formal analysis, Writing - review & editing.

Conflict of Interest

The authors of this manuscript declare that they have no conflict of interest.

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