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Case study

The study of binding agents used to inlay turquoise onto bronze objects in Eastern Zhou Period



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ABSTRACT

The paper presents the analysis results of the binding agents used on Turquoise-inlaid bronze artifacts in Eastern Zhou Period. The technique applied is pyrolysis-gas chromatography and mass spectrometry with thermal assisted hydrolysis and methylation (THM-Py-GC/MS). Mastic resin was identified as binding agent to inlay turquoise onto the bronze pots, based on the detection of the marker compounds of 3-oxo-olean-18-en-28-oic acid, 3-oxo-olean-12-en-28-oic acid and urs-2, 12-dien-28-oic acid. Beeswax was determined as the binding agent used on turquoise-inlaid bronze sword according to the detection of a series of alkanes, long chain fatty acids and long chain alcohols. The results clearly demonstrate that different binding agents were used to inlay turquoise onto artifacts respectively during Eastern Zhou Period in China.

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1. Introduction

During the past decades, a number of turquoise-inlaid artifacts were found in archaeological sites from Xia Dynasty (2100 BC–c. 1600 BC) to Eastern Zhou Period (770 BC–221 BC) [1,2]. The techniques and materials used to make these special artifacts cause great attention of archaeologists. In order to know how turquoise was inlaid onto bronze base, the identification of the binding agents used is crucial and decisive. Recently, lacquer was found as binding agents to inlay turquoise onto bronze pots from Shang Dynasty [3]. In another report, beeswax was identified as binding agent to inlay turquoise onto the handle of a sword from Chu State [4]. It would be very important to study whether other materials were used as binding agents to make those precious artifacts in ancient China.

Fortunately, two turquoise-inlaid bronze pots (H21, H22) found in a Chu tomb of the early time of the Warring States Period (5th–4th BC), located in Xujialing, Xichuan county in Nanyang of Henan Province [5] (Fig. 1) and a turquoise-inlaid bronze sword (labeled as TJ) excavated in Yuehe, Tongbai County in Nanyang of

Henan Province (archaeological No. 94NTYM1) (6th–5th BC) (Fig. 2) were available for this study.

The possible materials used as binding reagents in ancient China could be natural products such as drying oils, lacquer, gums, resins and waxes, etc. Lacquer can be classified according to the characteristic markers – urushiol, laccol and thitsiol [6]. Mastic gum is obtained by shallow incisions of the bark or the trunk and main branches of *Pistacia lentiscus* L. var. *Chia* [7]. Its main acidic fraction includes moronic acid, oleanonic acid, isomasticdienonic acid, masticdienonic acid, etc. [8,9]. The main composition of beeswax is made up of hydrocarbons, monoesters, diesters, triesters, hydroxymonoesters, hydroxypolyesters, monoacid esters, acid polyesters, free acids and free alcohols, etc [10,11].

The common techniques used to identify binding media in artworks or archaeological objects are gas chromatography coupled to mass spectrometry (GC/MS) [11–14]. Fourier transform infrared spectroscopy (FTIR), Raman spectroscopy were also applied. With the advantage of a relative simple sample preparation procedure, Py-GC/MS with thermal assisted hydrolysis and methylation technique (THM) were carried out for the characterization of samples in art works more and more [15,16]. This technique can be especially used to simultaneously characterize different materials such as drying oil, glue, resin, lacquer, wax, etc. [17,18]. Thus, THM-Py-GC/MS with in-situ methylation was chosen in this study, meanwhile, Fourier transform infrared spectroscopy (FTIR) was used as for a supplement method.

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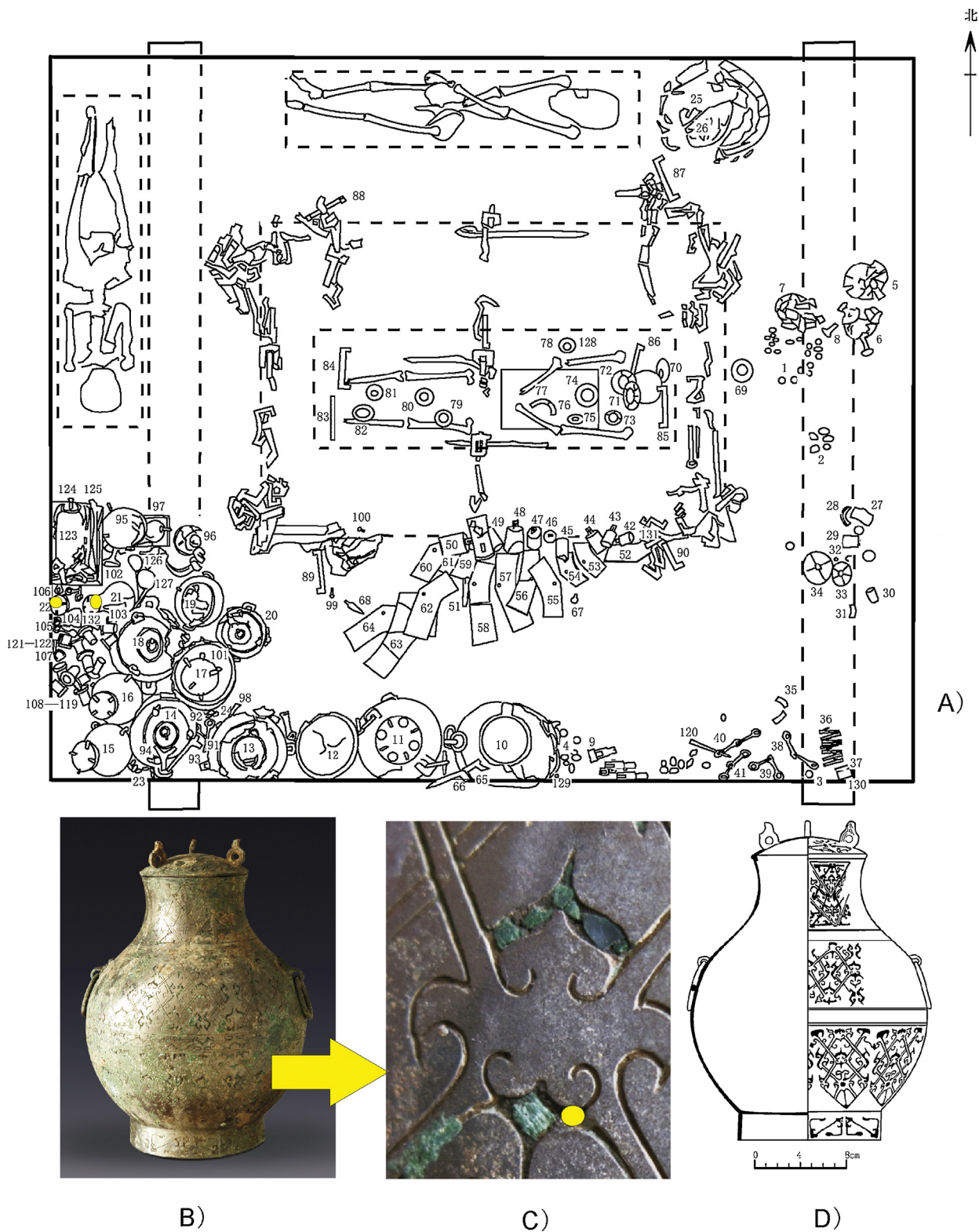


Fig. 1. A. Diagram of tomb M11, objects No. 21 and No. 22 indicates the two turquoise-inlaid bronze pots. B. Pot No. 21 (labeled as H21). C. Details of the turquoise-inlay on the bronze base. D. The plan diagram of the pot with cloud pattern decoration. The yellow point indicates where the sample was taken.

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