Journal of Archaeological Science: Reports 17 (2018) 212–219

Contents lists available at ScienceDirect

Journal of Archaeological Science: Reports

journal homepage: www.elsevier.com/locate/jasrep

Ancient glassware travelled the Silk Road: Nondestructive X-ray fluorescence analysis of tiny glass fragments believed to be sampled from glassware excavated from Niizawa Senzuka Tumulus No. 126, Japan

Yoshinari Abe[a,*], Ryuji Shikaku[b], Izumi Nakai[a]

[a] Department of Applied Chemistry, Faculty of Science, Tokyo University of Science, 1-3, Kagurazaka, Shinjuku-ku, Tokyo 162-8601, Japan
[b] Okayama Orient Museum, 9-31, Tenjin-cho, Okayama-shi, Okayama 700-0814, Japan

1. Introduction

The Niizawa Senzuka Tumulus Cluster is one of the most famous large tumulus clusters consisting of over 600 burial mounds located at Kashihara City, Nara Prefecture, Japan (Archaeological Institute of Kashihara, 1977). The burial mounds were constructed from the end of the 4th century through to the 7th century AD, and were especially in active use from the middle of the 5th century to the end of the 6th century. In 1963, two pieces of glassware, comprising a transparent facet-cut glass bowl (Fig. 1a and b, No. J-37204 at Tokyo National Museum) and a deeply blue-colored glass dish (Fig. 2a, b and c, No. J-37205), were excavated as grave goods from Tumulus No. 126 in the cluster. They had been placed together, overlapping, in a wooden coffin, resembling “a tea cup and a saucer” set. The burial date of Tumulus No. 126 is considered to be in the late 5th century based on the structural features and associated artifacts of the tumulus. Because no evidence of the primary glass production from raw materials in Japan dating prior to the late 7th century has previously been found (Koezuka, 2009; Nara National Research Institute for Cultural Properties, 1992), it is believed that all earlier glass products were imports produced overseas. In addition to the glassware, a lot of grave goods – such as gold or silver ornaments, iron swords and precious stones, indicating the deep connection between ancient Japan and the overseas – were excavated at Tumulus No. 126 (Archaeological Institute of Kashihara, 1977). All of these grave goods, including the glassware, are now designated as important national cultural properties in Japan and are stored in the Tokyo National Museum.

The glass bowl (Fig. 1a and b) is transparent pale-green in color, with a height of 6.7 cm, rim diameter of 7.8 cm, maximum diameter of 8.7 cm, and wall thickness of 1.0 to 1.5 mm (Archaeological Institute of Kashihara, 1977; Fukai, 1977; Taniichi, 1985, 2010). It has a round bottom, spherical body, constricted neck, and flaring mouth. It has five rows of round-shaped facets on the outer surface of its body, but first, third and fifth rows of the cuts have been left rough without smoothing. The mouth rim of the bowl was not treated by edge-fire-polishing or edge-fire-smoothing. These features indicate the possibility that the bowl was an uncompleted work (Taniichi, 1985, 2010). A number of glass bowls with similar shape and facet-cut decoration have been found in Roman sites (ca. 2nd–4th century) located on the coasts of the Mediterranean and the Black Seas and in Europe: Dura-Europos in Syria (Clairmont, 1963), Karanis in Egypt (Harden, 1936), Tanais and Panticapaion in Ukraine (Сорокина, 1965), Leuna in Germany (Harden et al., 1968) and Himlingøje in Denmark (Ekholm, 1963). etc. Conversely, similar glassware has also been unearthed in the region of Sasanian Empire (ca. 3rd–7th century): Tell Mahuz and Veh Ardašīr in Mesopotamia, Iraq (Negro Ponzi 1968–1969; 1984). Considering the strong technological influence of Roman Syria on Sasanian glass production (Shikaku, 2010; Simpson, 2014, 2015), it is possible that this type of glass bowl found in the Sasanian region was influenced by Roman glass products. Meanwhile, Taniichi (1985) has articulated the possibility that this type of glass bowl appears to have been introduced in the early stage of Sasanian glass production and became a predecessor of typical hemispherical glass bowls with deeply circular facets produced during the late-Sasanian period; this is known from a complete bowl in the Shōsō-in Treasury in Nara, Japan. Besides the Roman and Sasanian regions, several pieces of similar facet-cut glass bowls have been also found in China and Korea in Eastern Asia: i.e., Wulidun (Jiang, 2007), Chuncheng (An, 1986), and Datong (Wang and Wang, 2000) in China, and Hwangnam in Korea (Laing, 1991).

The deeply blue-colored glass dish (Fig. 2a, b and c) is a round, flat dish, with a diameter of 14.1 to 14.5 cm and a height of approximately 3 cm (Archaeological Institute of Kashihara, 1977). It has a ring base made by the stretching of the body, a common production technique observed in Roman glassware, e.g., discoveries at Karanis in Egypt (Harden, 1936). Conversely, and somewhat strangely, it has been reported that a West or Central Asian-style golden painting featuring a bird, a horse, a person, and plants was once drawn on the inner surface of the dish as shown in Fig. 2c, although the images have now been almost entirely worn away (Archaeological Institute of Kashihara, 1977). The incongruity between the features of the glass body and its painting has caused confusion about its provenance. However, we must allow for the possibility that the production and painting of the dish

* Corresponding author.
E-mail address: y.abe@rs.tus.ac.jp (Y. Abe).

https://doi.org/10.1016/j.jasrep.2017.11.005
Received 21 August 2017; Received in revised form 4 November 2017; Accepted 4 November 2017

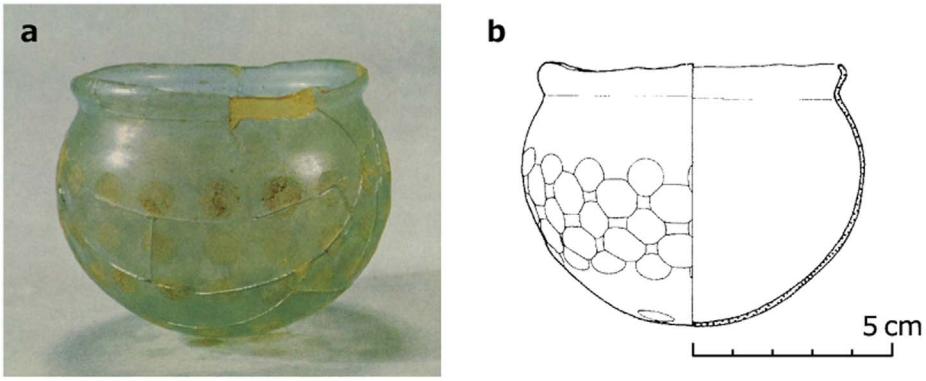

Fig. 1. A facet-cut glass bowl excavated from Niizawa Senzuka Tumulus No. 126 (No. J-37204 at Tokyo National Museum): (a) photograph; (b) line drawing. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
Reprinted from the excavation report by Archaeological Institute of Kashihara (1977).

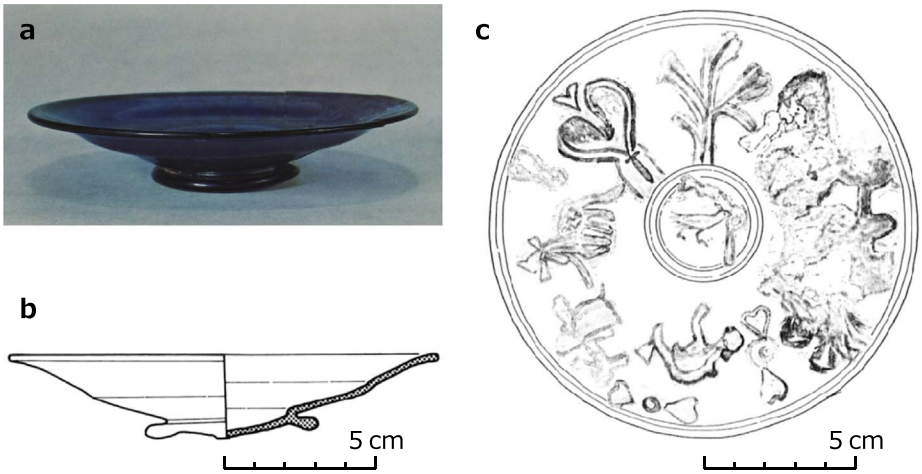

Fig. 2. A deeply-blue colored glass dish excavated from Niizawa Senzuka Tumulus No. 126 (No. J-37205 at Tokyo National Museum); (a) photograph; (b) line drawing; (c) reconstruction of golden painting on the glass dish. (For interpretation of the references to color in this figure legend, the reader is referred to the web version of this article.)
Reprinted from the excavation report by Archaeological Institute of Kashihara (1977).

were conducted at different places or times.

Both the glass bowl and dish are considered to have been produced by a free-blowing method, but no pontil mark remains on the bottom of the bowl in contrast to the dish, which has a small pontil mark on its bottom surface. These technical differences between the two glass items indicate the possibility they were produced at different locations or times.

Scientific research on the glassware had already been conducted by the National Museum of Nature and Science, Tokyo in the 1970s. Some small fragments and powder were sampled from the glassware after their restoration and used for several physical and chemical analyses (Oda, 1977). The measurements of refraction index and specific gravity suggested the use of alkaline lime glass for both glass items. For the facet-cut glass bowl, quantitative values of some major component elements were also obtained by means of classical chemical analytical methods, such as a titrimetry, by dissolving fragments. Through these methods, the bowl was found to have a soda-lime glass composition. In the middle of the 1st millennium AD, soda-lime glass was primarily produced in the two regions discussed above: the Roman (and early-Byzantine) Empire in the Mediterranean region and Sasanian Empire in West Asia. The glass products of these two regions can be easily distinguished by the chemical compositions of the different raw materials used, especially the soda flux. In the region west of the Euphrates, a mineral soda source, mainly “natron” from lower Egypt, was introduced into glass production as soda flux in the 10th century BC (Shortland et al., 2006). To the east of the Euphrates, by contrast, a plant ash flux was continuously used since the beginning of glass production (Brill, 1999; Smith, 1963). Moreover, several chemical compositional studies of Central Asian glass (Abdurazakov, 2009; Brill, 1999, 2009) have recently indicated the possibility of the primary production of soda-lime glass using plant ash in Central Asia through the ancient and medieval periods.

As outlined above, two pieces of the glassware excavated from Niizawa Senzuka Tumulus No. 126 can provide important evidence demonstrating how varied cultures were introduced to and accepted by ancient Japan. This study, therefore, aims to reveal the specific provenances of the glassware based on their chemical compositions. However, it is not easy to investigate chemically the glassware as they are designated as important national cultural properties in Japan.

Therefore, in this study, we focused on specimens of glass fragment believed as the rest of the fragments and powder sampled from the glassware excavated from Niizawa Senzuka Tumulus No. 126 in the previous scientific research conducted by Dr. Sachiko Oda of the National Museum of Nature and Science (Oda, 1977). The remaining samples of the research had been strictly stored by Dr. Oda herself, together with other cultural glass samples that she had previously analyzed. After her death, her collection of analyzed samples was carefully organized by the Association for Glass Art Studies, Japan (Yamahana and Inoue, 2010). We thus decided to analyze not the real bodies of the glassware but rather fragments believed to be sampled from them. Nonetheless, any destruction or damage on them should be avoided due to their preciousness. We, thus, applied several X-ray fluorescence (XRF) analytical techniques – using custom-made XRF spectrometers co-developed with an equipment maker and a high sensitive XRF analysis excited by synchrotron radiation – to the specimens to establish their detailed chemical composition nondestructively. Under the presumption that these specimens were actually sampled from the glassware excavated from Niizawa Senzuka Tumulus No. 126, specific provenances of the glassware were verified by means of comparison between our analytical results and literature data on Roman and Sasanian glass artifacts.