Medieval Workshop of an Alchemist, Jeweller and Glassmaker in Bilyar (Middle Volga Region, Russian Federation)

Středověká dílna alchymisty, klenotníka a skláře v Bilär (Střední Povolží, Ruská federace)

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…One just has to come into their world, imagine possessing a minimum of scarce substances available at that time in order to easily understand that there would have been no more reasonable explanation for that material; thus, we are fated to cherish the strength of mind of those alchemists who used to reach amazing conclusions while drawing on a miserable stock of facts…

I. I. Kanonnikov (1886)

In the centre of Bilyar, the pre-Mongolian capital of Volga Bulgaria, a team of researchers from Kazan University (Head – S. I. Valiulina) excavated and investigated an alchemy workshop – an example of an advanced experimental and craft alchemy practice. Some technological secrets from these experiments were determined using X-ray analysis (XRD) and scanning electron microscopy (SEM).

The considered artefacts and materials are representative of the workplace or 'production facilities' of an alchemist-craftsman who combined chemical experiments with a jewellery practice and who was capable of providing himself with the necessary special-purpose glassware. The scope of alchemy activity was determined using the analysis of alembics, as all other obtained materials are related to craft jewellery, which is quite common for Oriental alchemy as a whole.

Judging from the results of the stratigraphic analysis and the nature of obtained materials, the Bilyar workshop of an alchemist, jeweller and glassmaker functioned in the centre of Bilyar at the very end of the 12th century and the beginning of the 13th century. The majority of finds were in use for a long period of time. Archaeometric dating was performed for the following items: Iranian Kashin ceramics of a lustrous design and minai, Russian glass tumblers, a lamp and a bead necklace of semi-transparent yellow glass.

Finds of chemical glassware in Bilyar and other pre-Mongolian cities of Bulgaria and the discovery of the workshop of alchemist, jeweller and glassmaker in the centre of Bilyar informed the conclusion on the existence of alchemy in Volga Bulgaria in the 12th century to the beginning of the 13th century. Thus, archaeologists gained a rare opportunity to unveil the peculiarities of the initial stage of development of alchemy – experimental, craft or practical chemistry in eastern Europe.

medieval alchemy, Islamic glass, natural science methods, Volga Bulgaria, Bilyar

V centru Biläru, v předmongolském období hlavním městě Volžského Bulharska, nalezl a prozkoumal tým badatelů z Kazaňské univerzity (pod vedením S. I. Valiulinové) alchymistickou dílnu – příklad pokročilého experimentálního a řemeslného alchymistického pracoviště. Některá technologická tajemství experimentů byla určena pomocí rentgeno-fluorescenční spektrální analýzy (XRD) a rastrovacího elektronového mikroskopu (SEM).

Posuzované výrobky a materiály jsou typické pro pracoviště nebo výrobní vybavení alchymisty-řemeslníka, který spojoval chemické pokusy s praxí šperkaře a který byl schopen sám si vyrobit potřebné speciální skleněné nádoby. Sféra alchymistovy činnosti byla ohraničena použitím analýzy s pomocí alembiků, zatímco ostatní získané materiály se vztahují ke šperkařskému řemeslu, což je docela běžné pro alchymii Orientu.

Podle výsledků stratigrafické analýzy a povahy získaných materiálů soudě, dílna alchymisty, klenotníka a skláře fungovala v centru Biläru na samém konci 12. století a počátem 13. století. Většina nalezených předmětů byla využívána dlouhodobě. Archeometrické datování bylo provedeno u těchto nálezů: íránské kašínské keramiky s lustrem a minai (vzácný typ keramiky Středního Východu z íránského města Rey, předchůdce Teheránu), ruské skleněné číšky, lampy a korálů z poločirého žlutého skla.

Nálezy skleněných nádob určených k chemickým účelům z Biläru a dalších předmongolských měst Volžského Bulharska a objev dílny alchymisty, šperkaře a skláře v centru města Bilär potvrzují závěr o existenci alchymie ve Volžském Bulharsku ve 12. a začátkem 13. století. Archeologové tak získali vzácnou možnost odhalit svébytnost počátečního stádia rozvoje alchymie – experimentální, řemeslnické nebo pokusné chemie ve východní Evropě.

středověká alchymie, islámské sklo, metody přírodních věd, Volžské Bulharsko, Bilär

Fig. 1a. *Map of Volga Bulgaria. Drawn by S. Valiulina, technical support from G. Frolov. —* ***Obr. 1a.*** *Mapa Volžského Bulharska. Kresba S. Valiulinová, technická úprava G. Frolov.*

1. Introduction

The Volga Bulgarian state was formed in the 10th century in the Middle Volga and Kama regions. Its peak of development is estimated to be in the 12th century to the early 13th century (*Fig. 1a*), as suggested by the volume of international trade and the high level of craft development, including such technologically-demanding arts such as glass-making and glazed pottery.

This work presents the investigation of a workshop in the central part of the inner city of Bilyar, the capital of Volga Bulgaria.[1] Stratigraphically, the find was located at the top of the cultural layer, undisturbed by any building construction since the destruction of the city as a result of the Mongol invasion in 1236 AD, thus providing a great opportunity for research and reconstruction. Written sources provide no information about alchemy practices in Volga Bulgaria.

In the Middle Ages, multifunctional centres of experimental alchemy were closely associated with handicraft activities, primarily with jewellery and glassmaking. For example, in the 8th century and at the beginning of the 9th century, famous Arab alchemist Jabir ibn Hayyan (Geber) experimented with glassmaking (*Henderson — Loughlin — Phail 2004*, 461). Raymond Lully (1236–1315) called glass 'the first product of the philosophy of chemistry' (*Farmakovsky 1922*, 73). Alchemic practices were conducive to the accumulation of knowledge about chemical processes practiced by craftsmen.

[1] The reported study was partially supported by Russian Foundation for Basic Research (RFBR), research project no. 16-06-00453a.

2. Workshop topography, features

Numerous glass items from excavation XXVIII helped to identify the location of the glassmaking workshop in the given part of the settlement, and excavation XL (60 m^2) was initiated in the centre of the inner city, to the west of excavation XXVIII. Excavation XL yielded a pottery workshop for production of glazed ceramics. The full-scale manufacturing unit included a kiln, a pit for storing raw materials and a roofed workshop with fragments of throwing wheels. However, half-dugout living quarters were examined only partially, as they extended further northwards beyond the excavation's limits (*Valiulina 2014a*, 285–290).

Excavation XLI (208 m^2) was established to the northeast of excavation XL (*Fig. 1b*).

A 0.45–0.5 m thick cultural layer is represented by just one stratigraphic horizon of the pre-Mongolian era. The best part of the layer, as was the case at excavation XL, was seriously destroyed by long-term ploughing and trenching. We examined a number of features found beneath the tilled land, the majority of which were associated with the process of production. Of principal interest are the remains of small kilns in the central part (*Fig. 1b: K2, K3*) and at the western wall of the excavation (*Fig. 1b: K1*). As a rule, kilns were located in pits.

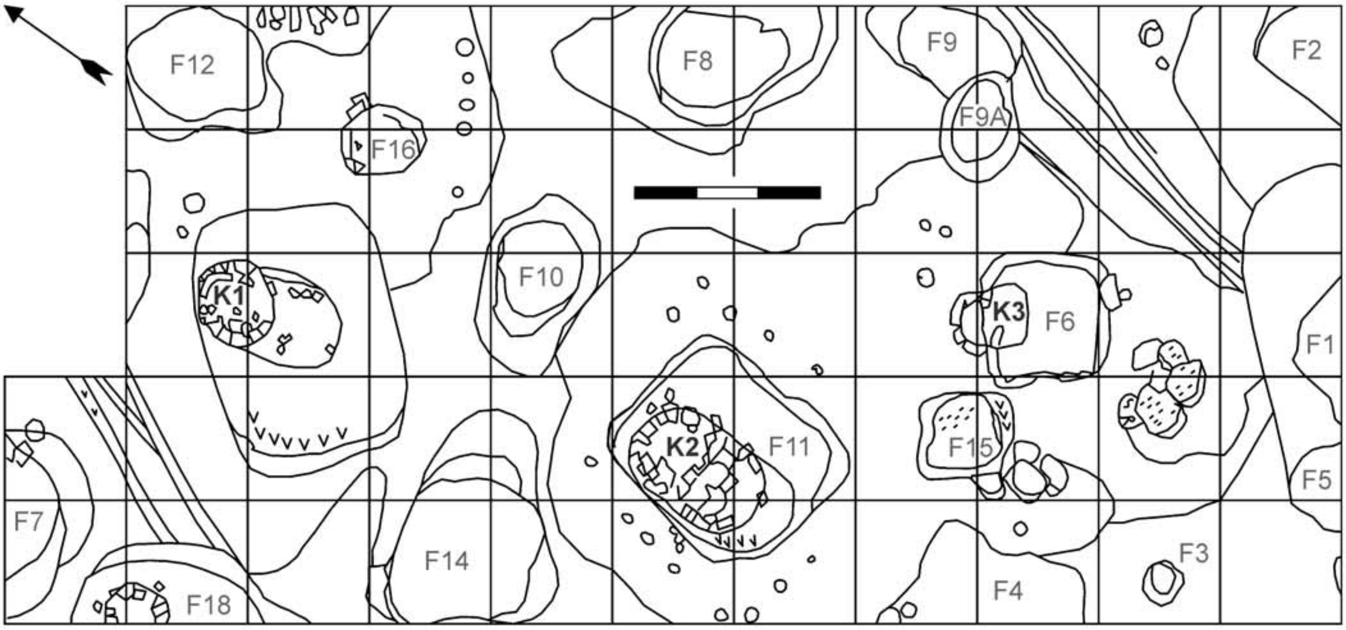

Fig. 1b. Alchemy workshop – layout. Bilyar excavation LXI. Drawn by S. Valiulina, technical support A. Frolov. — ***Obr. 1b.*** *Alchymistická dílna – situační plán. Bilär: výzkum LXI. Kresba S. Valiulinová, technická úprava A. Frolov.*

The contours of the latter were discovered at a depth of 40–45 cm on the subsoil surface.

Kiln no. 1 (*Fig. 1b: K1*) was discovered in a sub-rectangular pit (4.30 × 2.90 m). Fragments of the kiln found at a depth of 110 cm included an amassment of crushed brick, broken stone and a burned spot with a thick lens-shaped daub in the centre (*Fig. 11: 1*) smoothed and burned from the inside. The kiln's diameter was apparently about 1 m. Other finds included a few fragments of ceramics, brick rubble, a clay plug (*Fig. 10: 6*), coal, iron balls, ferrous and ceramic slag as well as two juxtaposed knives.

Kiln no. 2 (*Fig. 1b: K2*) was discovered in pit no. 11 (2.85 × 3.3 m) (*Fig. 1b: F11*), 160 cm below the contemporary surface. Oval in plan (1.4 × 2.0 m), one-level, twin-chambered and obviously arched, with a slightly extended southern side, the kiln was oriented strictly along the north-south axis. The upper part and walls are completely destroyed. The kiln's construction can be studied only from its base anchored into the pit's bottom to a depth of 55 cm. The kiln was built of standard construction bricks using limestone and sandstone slabs. It was most likely equipped with moulded Dinas bricks (*Fig. 10: 4, 5*). The wall thickness was about 20–25 cm. A partition wall divided the kiln along the west-east axis into two approximately equal (60 × 70 cm) chambers. The cup-shaped bottom of the kiln is lined with large stones and brick fragments. Gaps are filled with charcoal, fragments of firebricks (*Fig. 13: 3*), grating stones (*Fig. 12: 5*), alembics (*Fig. 3: 15*), sphero-conical vessels (*Fig. 16: 5*), and slag (*Fig. 13: 1, 2*). An ash and lime amassment contains eggshells and sherds of glass items, including fragments of alembics (*Fig. 5, 26, 28*). Post holes with a diameter of 5 cm suggest the presence of a fence.

In the opinion of T. A. Khlebnikova, one-level twin-chamber arched kilns were quite rare, as craftsmen used them to perform a limited amount of technological tasks (*Khlebnikova 1988*, 139).

Regular sub-rectangular pit no. 6 (2 × 2.1 m) (*Fig. 1b: F6*) holds kiln no. 3 (*Fig. 1b: K3*). The kiln's corners face the cardinal directions. A niche (40 cm width × 60 cm depth × 40 cm height) was discovered at the northwest wall of the pit at a depth of 110 cm, with the bottom lined with bricks and close-fitted stones with traces of burn deposits and soot. The niche obviously held a kiln. The fill of the kiln yielded pieces of coal, a (clay) puddle (up to 5 cm thick) from the kiln's arch (*Fig. 10*: *4*; *11: 1, 2*), a fragment of the bottom of a clay vessel with unworked liquid glass, pieces of lime, slag (*Fig. 13: 4–6*), an alembic (*Fig. 3: 2*) and a fragment of a grey clay sphero-conical vessel (*Fig. 16: 7*). At the bottom of the kiln, on the fragmentary clay puddle, the lower part of a massive glazed tripod (*Fig. 14: 14*) was cleared. On the southwest the kiln's pit neighbours pit no. 15 (*Fig. 1b: F15*), filled with lime and large slabs of crude stone.

Judging from coal heads, wood dust and post holes (15–20 cm in diameter) around the perimeter, the entire complex had a wooden stationary covering.

Several poorly preserved traces of fireplaces (pits) with burned spots, sandstone plates and brick rubble testify to vigorous handicraft activities in the given area.

Although both in terms of design and fill material, the kilns of excavation XLI are not kitchen ovens, they definitely differ from the known Bilyar pyrotechnological units: pottery (*Kokorina 1983*, 50–67), metallurgical (*Halikov 1976*, 64–74) and glassmaking (*Valiulina 2003*, 444–450). Small ground ovens are similar to the so-called 'philosophers ovens' used by alchemists. Albert the Great described the process of constructing such an oven: 'Dig a pit one cubit deep, about two cubits or a bit more wide, line it around and above with potter's clay. Fence the pit with a round wall and line it with potter's clay, too… Then use potter's clay to make a disc which would resist heavy fire… A clay tripod stand should be installed above the disc. The tripod should accommodate vessels with all kinds of substances intended for firing, whereas embers should be placed under the tripod stand' (*Albert the Great /Rabinovich 1983*, 354/). Instead of special tripod stands, craftsmen sometimes used wide-open, three-legged, cup-shaped vessels (*Fig. 14: 12–15*). Several such vessels were discovered during the excavation. In 1934–1935 in Suvar, A. P. Smirnov discovered fragments of alembics, about 40 sphero-conical vessels as well as fragments of large plain three-legged stands made of refractory clay. The lower parts and legs of the latter were covered with a glazed film of a dirty green colour formed under the influence of high temperatures and the kiln's atmosphere.[2]

According to prescriptions, all alchemic operations 'should be performed in cold and humid places' (*Albert the Great /Rabinovich 1983*, 361/). The ground units of excavation XLI met the abovementioned requirements. Apparently, cold and humidity were accompanied by darkness, which is proven by numerous finds, including clay lamps (58 specimens, either intact or in fragments, *Fig. 14: 1–8*) and a glass funnel-shaped lamp/lampad (*Valiulina 2005*, fig. 23, 5). However, lamps and oil and petroleum burners could also have been used as heaters (*Karimov 1957*, 62–63, 107, 124; *Tiflisi /translation Mikhalevich 1976*, 128/; *Poisson 2002*, 204).

3. Glass

Like today, special-purpose glassware held great significance. The sixth prescription in Albert the Great's *Libellus de Alchimia* strongly advises that 'vessels intended for operations with water and oils, whether with or without the use of fire, should be either made of glass or glazed from the inside. Otherwise, many evils will befall. Thus, should acidic waters be poured into a copper vessel, the latter's walls would turn green; should they be poured into a vessel made of iron or lead, the walls would turn black because of damnation (inficiuntur). In the case of a clay pot, acidic waters would penetrate through porous walls and the entire undertaking would be irretrievably ruined' (*Albert the Great /Rabinovich 1983*, 353/). Ar Razi also insists on the use of glassware in alchemy practice (*Karimov 1957*, 121, note 34). The same requirement applied to pharmacy. For example, S. v. Osten cites relevant prescriptions from Pharmaceutical Regulations adopted in the city of Passau in 1588 on the prohibition of storage of solutions in vessels made of copper and other metals (*v. Osten 1998*, 86).

With regard to the glassware of medieval Armenian alchemists, T. T. Kazandzhyan cites one of the Matenadaran manuscripts: 'And I will tell you about the vessels we need in our art; these are vessels for the preparation of salts, vessels for heating substances, and glasses, and glass, and glass mortars for grinding substances…' (*Kazandzhyan 1955*, 136: Matenadaran manuscript no. 8314, 184).

Libellus de Alchimia contains over 30 references to glass, and Ar Razi pays great attention to it as well. He often writes specifically about 'Syrian' glass, one of the best in the medieval East not only in terms of its excellent outer appearance – purity and transparency – but above all in terms of technical characteristics and high chemical endurance. The German physician and chemist Andreas Libavius (second half of the 16th century – beginning of the 17th century) writes about ovenware: 'A substance placed in a vessel made of thoroughly double-melted and blown glass can resist fire for a great while' (*v. Osten 1998*, 67).

Close affinity between alchemic and handicraft practices is also justified by the example of the workshop of the end of the 13th century, found at the outskirts of Marseille (*Thiriot 1997*, 515–516, 521).

Excavations at the site of an alchemy laboratory from the 16th century in Oberstockstall (Austria) yielded numerous glass laboratory dishes and other glass items, including window screens (*v. Osten 1998*, 200–223, Taf. 46–57, 71–75).

Excavation XLI yielded over 300 fragments of various items made of glass, including 35 alembics. A total of 29 alembics were found in a hoard (*Fig. 15: 2*) in the southeast part of the excavation, in the unconsolidated fill of pit no. 9a. The vessels were stored in a corner, presumably, in a birch bark box. It should be noted that the given complex yielded mostly intact alembic (*Fig. 3: 19; Fig. 4: 8*) samples: one was restored totally, others were represented as exact graphic reproductions (*Fig. 4: 1, 3, 4*). Apart from alembics, the hoard included other interesting items: three touchstones (*Fig. 17: 9–11*), 27 sheep astragals (*Fig. 15: 4*), either perforated or somehow processed, an iron axe (*Fig. 15: 3*), a bronze key (*Fig. 15: 1*), an anthropomorphic object made of green schist – a figurine of a Tengri (*Fig. 15: 5*).

The hiding of hoards in ancient times involved the pronunciation of various spells and performance of magic rites aimed at making the hoard inaccessible. N. A. Makarov provides a vast list of hoards containing axes, keys, locks, spearheads and other metal objects (*Makarov 1981*, 262–263). The presence of such items in hoards is explained by an ancient belief in their magical properties. Prior to their placement in a hoard, locks, axes or keys were subjected to ritual 'locking' – they had to be placed in a magical circle circumscribed by an axe, a knife or a sword.

However, apotropaic magic included not only rites intended to ward off harm or evil influences, but actual items used to avert evil – protective amulets and mascots. The abovementioned figurine of Tengri – a celestial deity or 'sky god', is responsible for the preservation of the soul and property of people. Tengri is often associated with the Buddhist epithets 'self-emerged', 'emerged unseen', 'lacking arms and legs' (*Fig. 15: 5*). Thus, the hoard of alembics was hidden in full compliance with the rules. However, it was not claimed by the owner and survived in its original state. The time of the burial of the hoard was established stratigraphically. The hoard dates to the moment of the demise of the city as the result of fire and devastation during the Mongol conquest in the autumn of 1236. The complex testifies to the high

[2] State Historical Museum, no. 77070, inv. 687/7903; no. 77908, inv. 2189/1185.

value of glass products, as they deserved to be hidden. The presence of touchstones is further proof of a close connection between alchemy and jewellery handicraft practices.

3.1. Alembics

Written sources provide no information about alchemy practices in the Volga Bulgaria. However, judging from alchemy treatises by Oriental and west European authors, alchemy was one of the main medieval sciences. Alchemists recorded detailed accounts of recipes and technologies for the production of various alloys, drugs, elixirs and beauty aids with drawings and lists of the necessary laboratory equipment, including chemical glassware (*Dzhanpolyadyan 1974*, 39).

Distillation is an ancient technological-chemical operation. Primitive vessels for distillation found in Mesopotamia date to the third millennium BC. One of the earliest descriptions of the given procedure is provided by Dioscorides (1st century AD), who recorded the distillation of mercury isolated from cinnabar and gave the name to a retort-shaped vessel necessary for this operation – ambix (*General History of Chemistry 1983*, 391). The first such vessels were probably made of bronze (*Maslenitsyna 1975*, no. 54).

Tashtyk antiquities of the Early Iron Age in South Siberia include wooden vessels reminiscent of large alembics. E. V. Vadetskaya calls them 'flagons' – 'kettles' with nozzles (*Vadetskaya 1999*, 41, fig. 22: 12). According to S. v. Osten, the first glass alembic obtained at the Cyprus complex of the 2nd century AD (*v. Osten 1998*, 72) was mistakenly named 'guttus' by the author of the excavation (*Nicolaou 1971–1972*, 133–134).

The names 'lambics-alambics-alembics' are used in different Oriental regions (from Arabian 'al-inbig'); ar Razi used the word 'ambic' – vessel with a trunk, alambic (*Karimov 1957*, 161); lombics – in Hungary (*Termeszettudomanyi Kislexikon A–Z 1976*, 713); 'Destillierhelm' – 'distillation helmet' or 'distillation cap' – in late medieval Germany (*Huwer 1992*, 136, Abb. 194); glass and glazed clay vessels in 16th-century Austria (*v. Osten 1998*, 31, Abb. 13; Taf. 1, A 1). Since the Early Middle Ages, alembics are available from the archaeological complexes of Egypt, Iraq, Iran, Transcaucasia, Central Asia and China. In the 9th–13th centuries they gained in popularity across the entire Muslim world (*Lamm 1929–1930*; *1935*; *Dzhanpolyadyan 1974*, 40; *Abdurazakov — Bezborodov — Zadneprovsky 1963*, 131–133; *Amidzhanova 1961*, 249, 251; *Fomenko 1962*; *Chkhatarashvili 1978*, 87, table V, 12–14; *Shishkina 1986*, 15, fig. 1, 13; *Kröger 1984*, 17, 18; no. 14; *1995*, 185–187, no. 239–243; *Han Han 1999*, 76; *Auth 1976*, 178, fig. 248; *Whitehouse 2001*, 78, no. 8; *Carboni 2001*, 144–145, Cat. 34c).

G. M. Akhmedov describes Bailakan alembics as 'little snorters with a long nozzle of original form' (*Akhmedov 2003*, table 190: 8, 384). In Georgia alembics are sporadic (*Chkhatarashvili 1978*, 95, tab. V: 12–14), of Iranian origin and dating to the 9th–11th centuries (*Ramishvili 2003*, 313). In the Volga Bulgaria alembics are known in large pre-Mongolian cities – Suvar[3] (*Fig. 6: 4*) (*Smirnov 1951*, 260; *1941*, 166), Bilyar (*Valiulina 2005*), Murom town in Izmeri. One alembic was recently obtained during excavation work led by V. S. Baranov in Bulgar. Alembics are the most abundant glass vessels in both Bilyar and Bukhara (*Abdullayev 1981*, 56). The distribution of the found alembics with the features of the Bilyar settlement reflects the spheres of their application. Basically, alembics are available from excavations XXVIII (90 specimens) and XLI (35 specimens), i.e. from the handicraft centre of the capital city, as in Suvar.

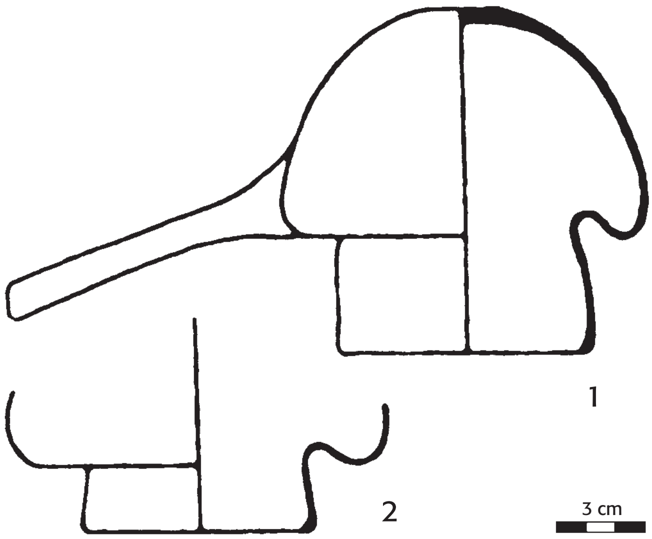

Fig. 2. *Alembic, type 1. Bilyar. A. Khalikov excavations XXXVIII biennium. Б XXXVIII/750. Drawn by T. Valiulin. —* ***Obr. 2.*** *Alembik, typ 1. Bilär. Výzkum A. Khalikov (XXXVIII. biennium). Kresba T. Valiulin.*

The Bilyar settlement collection contains about 150 alembic samples (fragments and archaeologically intact vessels). Initially some fragments were mistakenly identified as 'fragments of bracelets made of hollow tubes' (*Halikov 1979*, 20, table VII: 10, 11). The majority of vessels are blown from light green-blue glass of various intensity and tint. Six fragments are of an olive colour, while four vessels are colourless. Glass is transparent or slightly matte, with numerous vertically drawn bubbles and almost no patina or irisation on the surface due to high glass durability. Decoration is lacking on all of the vessels.

Alembics and test tubes were made using the blowing and drawing method based on a successive combination of the blowing and drawing processes. Bubbles on finished products are of an extremely eccentric oval shape. Both the body base and nozzle tube are made using the given method. The only difference between the two components in the first stage was the tube diameter. Next, the separately produced rundown pipe had to be connected to the outlet in the upper part of the body with the use of an additional piece of glass. The edge of the nozzle tube is sheared and fire-polished. There is a substantial thickening at the junction of the rundown pipe and the body due to the excess reserve of glass.

[3] About 10 fragments kept at the Central Museum of the Tatar Republic; no. 5666-7, no. 5666-4.

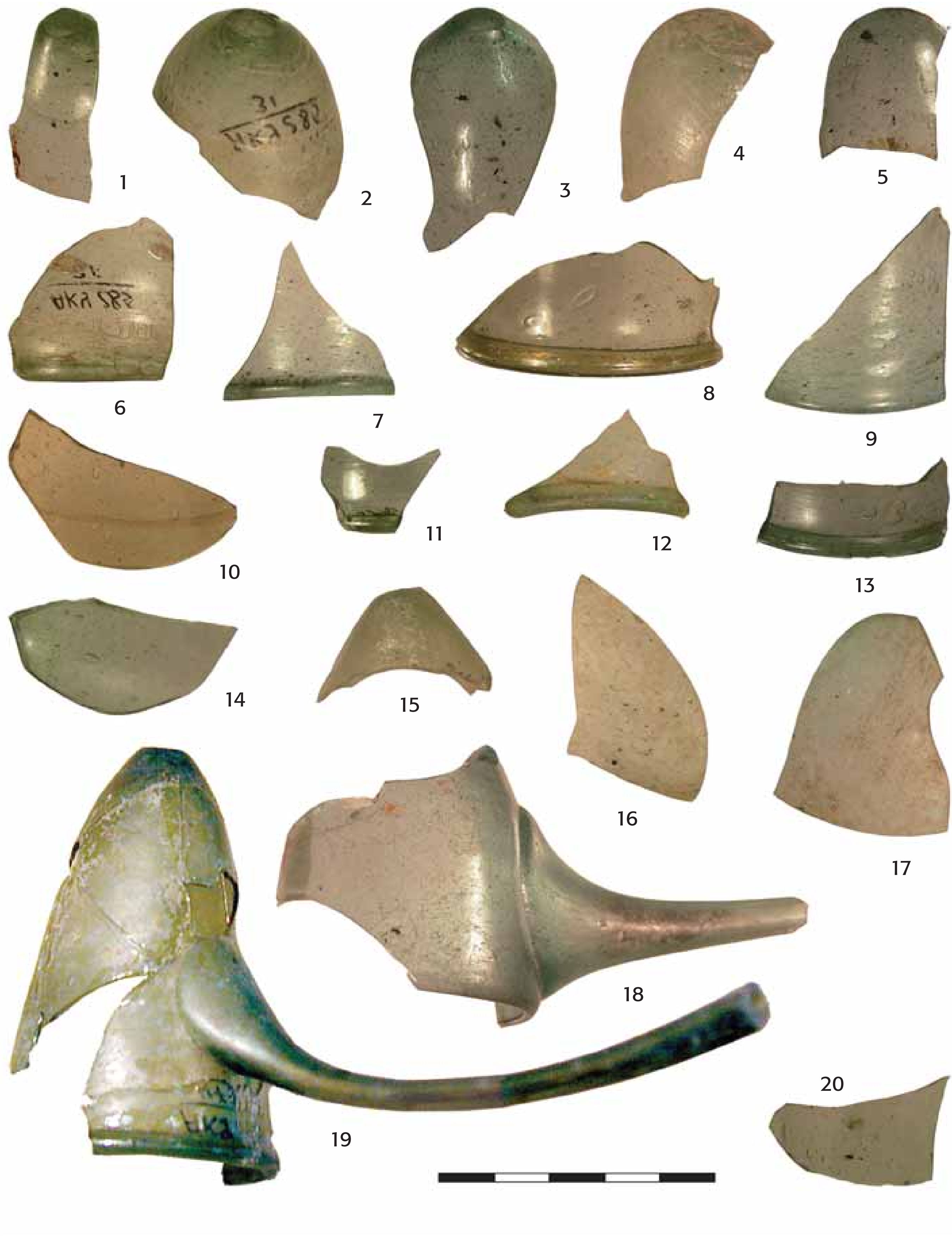

Fig. 3a. *Alembics, type 2. Bilyar (after S. I. Valiulina 2005, Fig. 15: 1–20). Photo by T. Valiulin. —* ***Obr. 3a.*** *Alembiky, typ 2. Bilär (podle S. I. Valiulina 2005, obr. 15: 1–20). Foto T. Valiulin.*

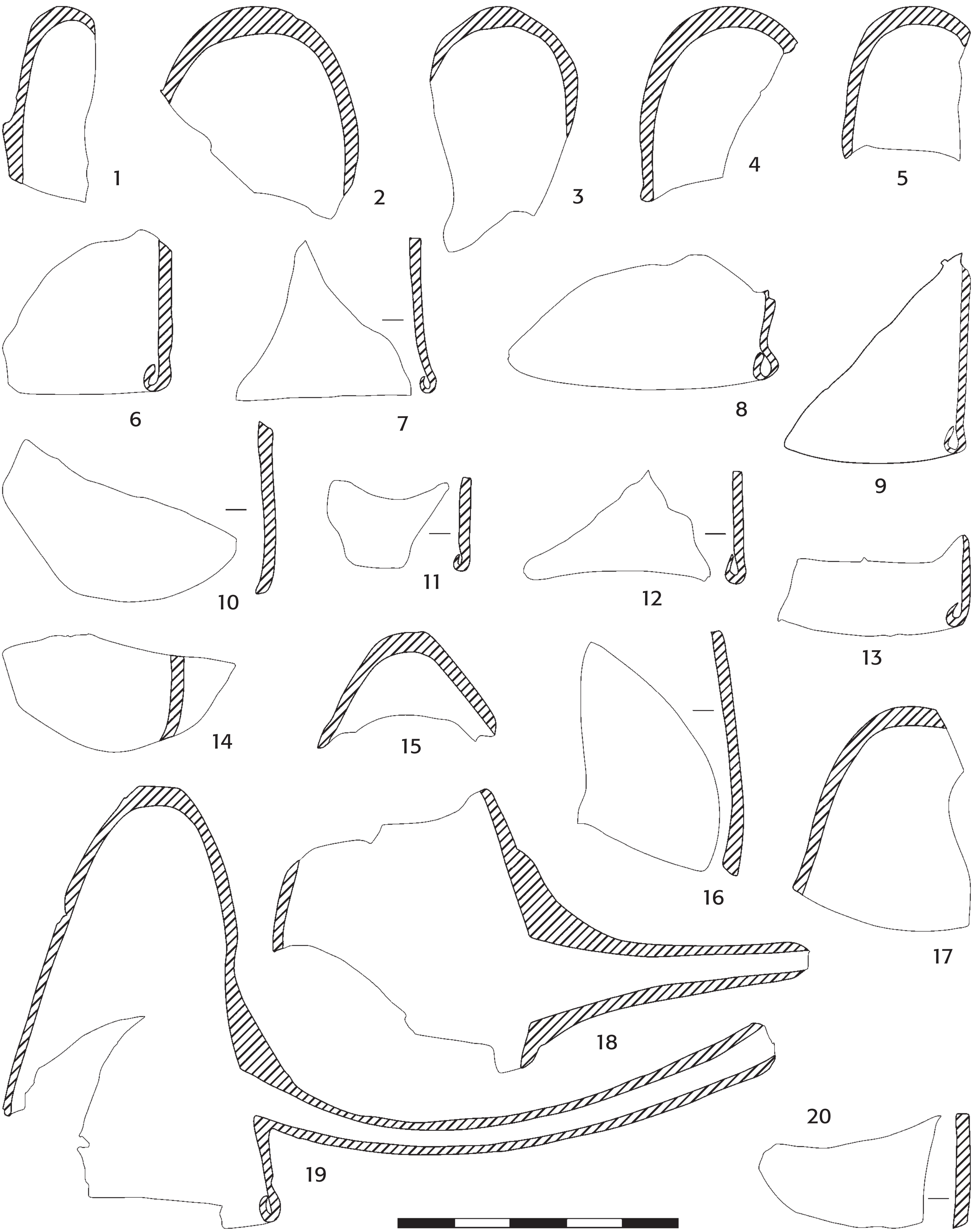

Fig. 3b. *Alembics, type 2. Bilyar. Profiles from Fig. 3a. Drawn by T. Valiulin. —* ***Obr. 3b.*** *Alembiky, typ 2. Bilär. Profily z obr. 3a. Kresba T. Valiulin.*

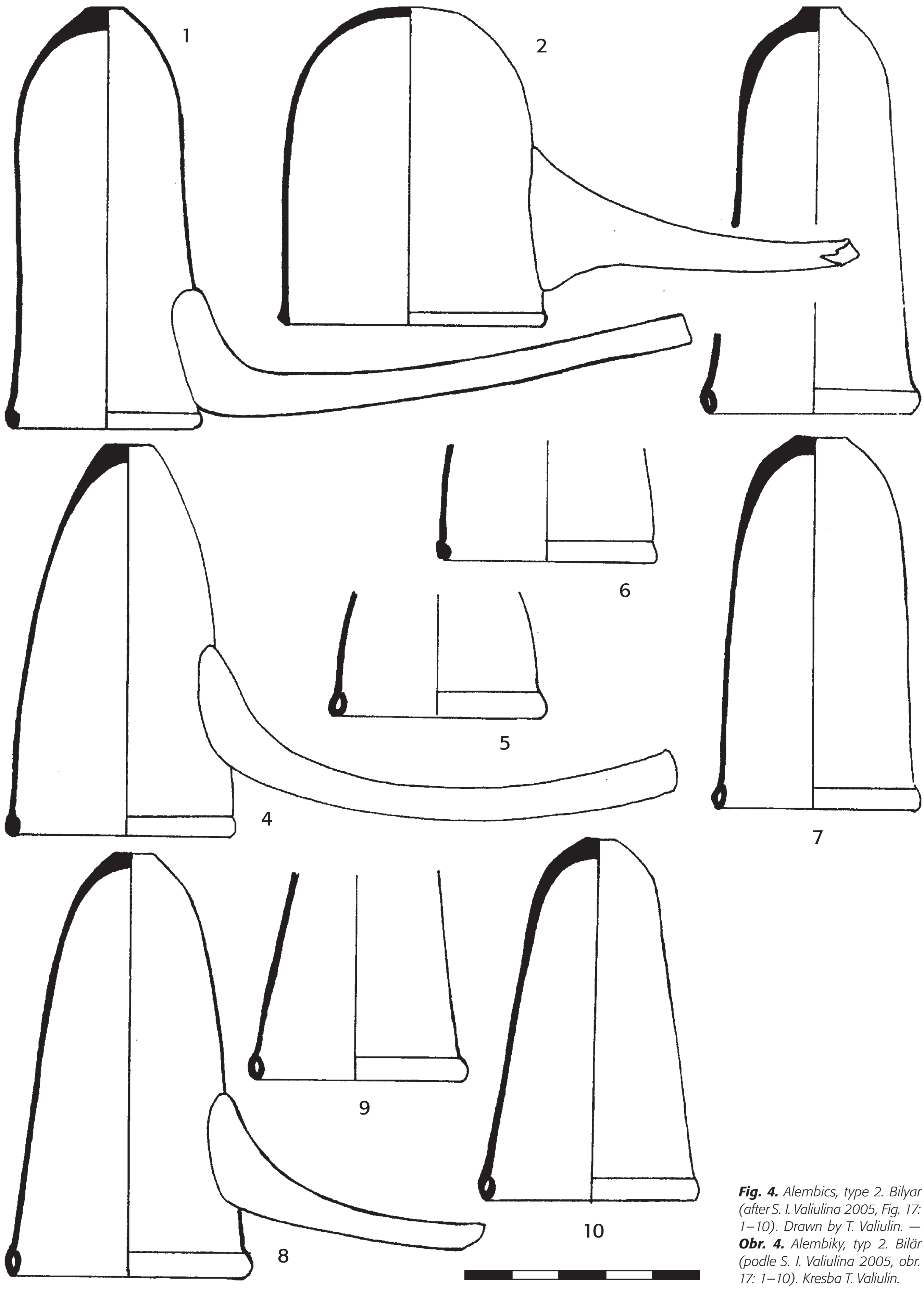

Fig. 4. *Alembics, type 2. Bilyar (after S. I. Valiulina 2005, Fig. 17: 1–10). Drawn by T. Valiulin. —* ***Obr. 4.*** *Alembiky, typ 2. Bilär (podle S. I. Valiulina 2005, obr. 17: 1–10). Kresba T. Valiulin.*

The reheated tubes of the finished alembic were then curved, whereas the free end of the tube received a vertical orientation in relation to the horizontal line of the edge of the alembic's collar. As already mentioned, all Bilyar alembics are very standard. Their tubes are always curved in the same direction, albeit at different angles. The bodies of certain alembics differ, as they were blown into the forms (possibly, clay crucibles) using rotation. Such vessels have a matte surface, with traces of rotation and cylinder-shaped bubbles. Excavation XLI yielded both alembics and crucibles that are commensurate in form. Central Asian alembics were also produced by blowing in a form using rotation (*Abdurazakov — Bezborodov — Zadneprovsky 1963*).

There are two types of Bilyar alembics:

Type 1. Armenian alchemy treatises refer to alembics with a dome-shaped 'pumpkin' (*Dzhanpolyadyan 1974*, 40). The Bulgar collection of glass includes a fragment of one such vessel from Bilyar[4] (D1 = 8.3; D = 13), which used to be part of a distillation apparatus (*Fig. 2*). The mushroom-shaped alembic consists of two components – a high straight cylindrical collar and a mushroom-shaped dome of a larger diameter. The rundown pipe is attached at the junction point (smooth fold) of these two components. In the course of the distillation process, the above-mentioned fold accommodated drops of liquid, which were then transferred to a decanter. The given process can be illustrated by the schematic illustration of the distillation apparatus invented by Leonardo da Vinci (*Huwer 1992*, 136, Abb. 194).

Distillation apparatuses of a similar construction produced the rosewater widely used in medicine and cosmetics (*Dzhanpolyadyan 1965*, no. 2, 213). Glass vessels similar to alembics but with narrower necks – 'pulverisers or smoking pipes' – are known from medieval India (*Chidambaran 1969*, 134, fig. 222: 13, 14).

Type 2. Alembics (*Fig. 3: 1–20*; *4: 1–10*; *5: 1–30*; *6: 4*; *15: 2*; *16: 1*) – small cylindrical or cone-shaped glass vessels (7–10 cm in height, collar diameter from 3.5 to 6 cm, most often from 4 to 4.5 cm) with an extremely narrow, slightly bent and inwardly curved, sometimes straight, roundish, slightly liquated, edge of the collar, conic or round bottom, with a wall thickness increasing towards the bottom; the bottom often bears traces of the delicate removal of the pontil. A sharply curved or almost straight, parallel to the horizontal line of the collar, rundown pipe of 8–11 cm in length, is attached to the upper part of the vessel, 0.8–1 cm from the edge of the collar. Bilyar alembics are distinguished by their rundown pipes, which are originally curved to meet the requirements for the vessels' placement during the process, as well as by explicit uniformity as the result of the established standardization of forms and dimensions of the vessels, by their large numbers, by the colour of the glass and the absence of decoration.

Apparently, type 2 alembics are all-purpose vessels – they could be parts of a distillation apparatus, such as type 1 alembics, or could be used for pouring liquids into narrow-necked vessels such as sphero-conical vessels. Some experts suggest that they could also have been used for medical purposes (*Mukhametzhanov et al. 1988*, 178). One Bagdad miniature depicts an alembic as a bloodletting device (*Dzhanpolyadyan 1974*, 40). During the Early Middle Ages in the countries of the Arab East 'bloodletting cans were made not of glass, but of metal, more often from bronze' (*Metz 1973*, 216).

According to J. Kröger, sphero-conical vessels and alembic caps found in Nishapur homes of the 9th–10th centuries could have been used for the household production of rosewater, date wine or for sherbet, whereas their main purpose had to do with pharmaceutics and the alchemy practice (*Kröger 1995*, 186–188). Other experts also support the idea of a wide application of alembics (*Thomas 2009*).

However, the performance capabilities of type 2 alembic caps in the process of distillation are often considered to be insufficient. With the aim of testing the hypothesis of the use of the combination of sphero-conical vessels and type 2 alembics as a distillation apparatus, the following experiment was conducted during the seminar 'Technology of Medieval Handicrafts' hosted by Kazan University. A clay sphero-conical vessel was positioned on a stand. Its head accommodated a replica of a glass alembic, and the end of the alembic tube led to the decanter (a glass flask was used instead of the second sphero-conical vessel, to make the distillate visible). An alcohol lamp was lit under the entire unit. The sphero-conical vessel was installed at an angle, with regard to the curve of the alembic tube, to facilitate the draining process. Water was used as a distillation fluid (*Fig. 23*). The experiment proved the possibility of using such a unit for distillation purposes (*Nuretdinova — Valiulina 2015*, 153–155).

In fact, all connecting points of the three vessels would have been thoroughly sealed with special clay or egg white (*Thomas 2009*, 36).

Alembic caps could have been used to solve more complex tasks, as the alteration of the angle of the entire unit ('sphero-conical vessel' form is well suited for such variations) ensured better purification or separation of mixtures. The strictly vertical installation of the sphero-conical vessel with the mother substance and the type 2 alembic in the first stage of distillation, and alteration of the tube angle in the second stage allowed for redistillation and rectification. Rectification (lat. *rectus* – 'straight' and *facere* – 'to make') is the separation of binary or multi-component mixtures on the basis of differences in boiling points, when a certain part of the liquid condensate is constantly returning to the source vessel while moving against the steam. As a result of the given process, various admixtures present in the steam return to the source vessel, leading to an increase in the purity of the steam and condensate. The form of the inner crosswise fold-free alembic cap (type 2), with almost vertical straight walls, perfectly suited the given procedures.

Bilyar alembics of both types are most similar to the 9th–11th-century vessels from the Armenian city of Dvin. Central Asian alembics are of different sizes and proportions (D = 4.0–5.4 cm; H = 4.5–5.1 cm).

[4] Bilyar Museum, BXXXVIII/750. BM, BXXXVIII/750.

Fig. 5a. *Alembic tubes. Bilyar (after S. I. Valiulina 2005, Fig. 16: 1–30). Photo by T. Valiulin.* — ***Obr. 5a.*** *Trubice alembiků. Bilär (podle S. I. Valiulina 2005, obr. 16: 1–30). Foto T. Valiulin.*

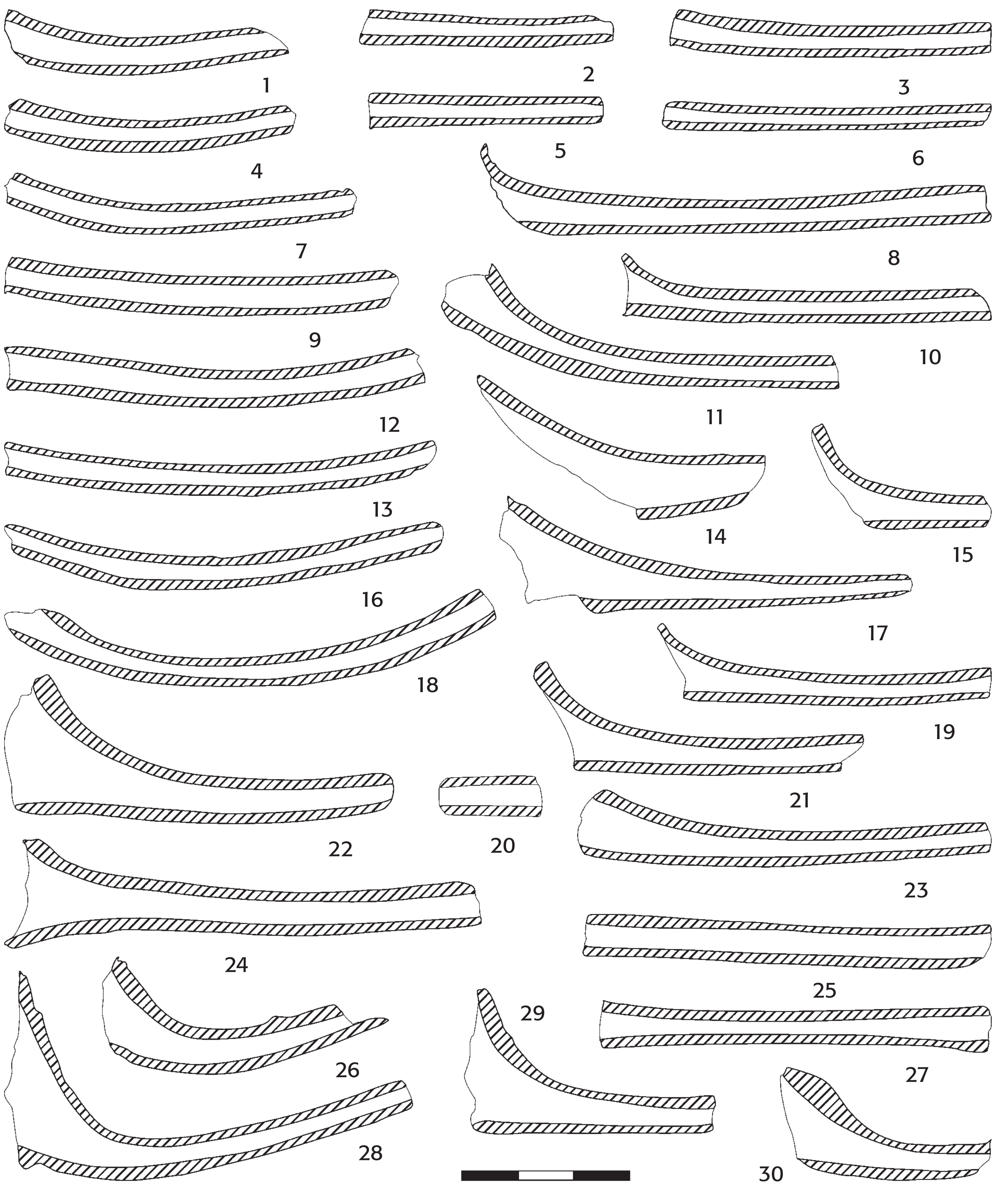

Fig. 5b. *Alembic tubes. Bilyar. Profiles from Fig. 5a. Drawn by T. Valiulin. —* ***Obr. 5b.*** *Trubice alembiků. Bilär. Profily k obr. 5a. Kresba T. Valiulin.*

Bilyar alembics date to the upper horizon of the cultural layer – the 12th century to the beginning of the 13th century.

With regard to morphological unity, alembics from Suvar and other Volga Bulgarian cities should be dated to the same historical period.

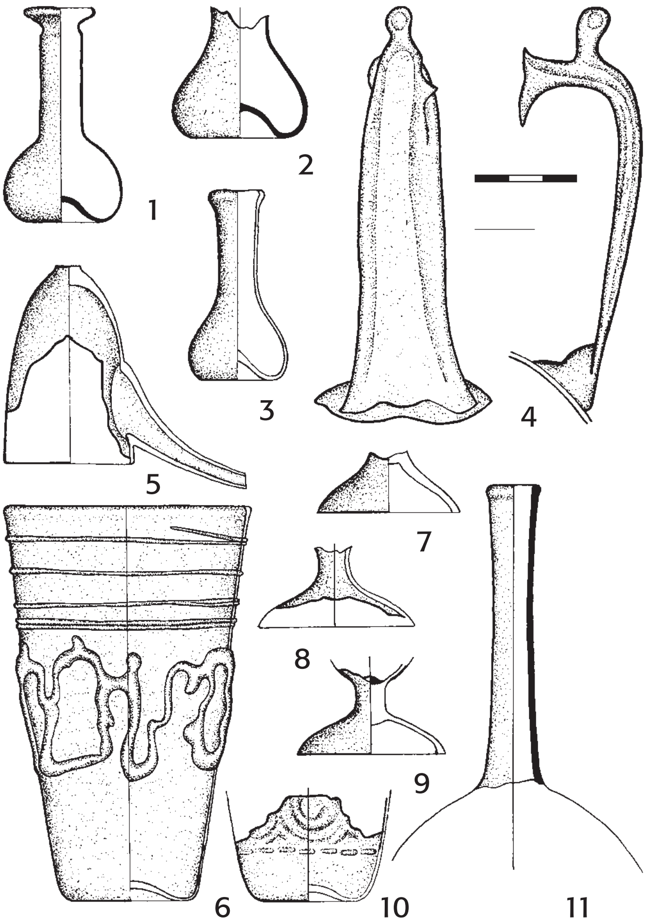

Fig. 6. *Glassware from Suvar:* ***1–3*** *– miniature bottles;* ***4*** *– vessel handle;* ***5*** *– alembic;* ***6, 10*** *– cups;* ***7–9*** *– foots of glass-vessels;* ***11*** *– bulb.* ***1–11*** *(after S. I. Valiulina 2005, Fig. 19: 1–11). Drawn by T. Valiulin. —* ***Obr. 6.*** *Skleněné zboží ze Suvaru:* ***1–3*** *– miniaturní lahvičky;* ***4*** *– ucho nádoby;* ***5*** *– alembik;* ***6, 10*** *– číšky;* ***7–9*** *– nožky skleněných nádob;* ***11*** *– vysoké hrdlo skleněné baňky.* ***1–11*** *(podle S. I. Valiulina 2005, Fig. 19: 1–11). Kresba T. Valiulin.*

3.2. Test tubes

A test tube fragment[5] (*Fig. 8: 2)* obtained at Bilyar excavation XXVIII in the immediate vicinity of an alchemy workshop (Excavation XLI) in the layer from the 12th century to the beginning of the 13th century has a roundish edge, straight collar – continuation of the walls, and cylindrical body truncated from above (no information about the bottom). Dimensions: $D=D_1$ = 3 cm; H = at least 7 cm. The 1.5 mm transparent glass is of a light-green colour. Glass test tubes are also found at Central Asian sites (*Abdurazakov — Bezborodov — Zadneprovsky 1963*, 134). The cone-shaped bottoms at Bulgar most probably also belonged to test tubes (*Polyboyarinova 1988*, 204, fig. 88: 6).

3.3. Spherical-conical vessel

The spherical-conical vessel found in Bilyar[6] (*Fig. 8*: *3*) was made of dark glass. The wall thickness was 0.8 cm, the outlet diameter 0.4 cm, and the outer surface bears a 'bird feather' image imposed with white enamel against the previously scored base. Following Roman traditions, in the 7th–13th centuries the bird feather painting technique gained in popularity among Egyptian, Syrian (*Art of Islam 1990*, 64) and Byzantine craftsmen (*Dzhanpolyadyan 1965*, 205; *1974*).

Certain finds of glass sphero-conical vessels are known from Central Asia and Transcaucasia. Al-Biruni probably referred to precisely these kinds of vessels while describing his method of the revival of pearls (*Al-Biruni* /*Belenitsky 1963*, 121/). Also known are sphero-conical vessels from the Rasulid sultans of Yemen (*Porter 1998*, 93, fig. 21.1) and Mamluk, Egypt (*Newby 1998*, 38, fig. 10: 1–4), which are perfect in shape and painted with enamel glass.

A fragment of a Syrian vessel from the 13th century held at the Hague Municipal Museum is the closest parallel to the fragment of the Bilyar sphero-conical vessel (*Lamm 1929–1930*, 291, Tafel 109: 4).

Glass sphero-conical vessels are very rare, a fact that S. E. Mikhalchenko attributes to the fragility of the material and relatively poor market demand (only by alchemists) (*Dzhanpolyadyan 1982*, 15). While the first argument holds ground, one may not agree with the second. That glass sphero-conical vessels could not compete with less expensive, more durable and reliable clay versions is another matter altogether. Numerous finds of clay sphero-conical vessels in medieval Oriental handicraft centres are widely known (*Mikhalchenko 1974*, 50). So far, Bilyar sites have yielded several hundreds of such finds (both fragmented and intact) (*Halikov 1986*, 74), and Suvar sites have yielded several dozens (*Smirnov 1941*, 162–163).[7] Red-clay sphero-conical vessels of apparently local origin are also readily available from Bulgar.

3.4. Flasks

Tall, closed vessels with high and narrow necks and either a sphero or roundish cone-shaped (truncated from below) body were highly popular in the medieval East (*Abdurazakov — Bezborodov — Zadneprovsky 1963*, 133; *Kudryavtsev 1993*, 233, fig. 64: 23; *Shishkina 1986*, fig. 11: 3, 8). Bulgar sites yielded one sample from Suvar[8] – with a roundish cylindrical straight neck, somewhat narrowed in the middle, and a rounded edge (H = 9.2 cm, D = 1.5 cm, wall thickness 1.5 mm). The glass is transparent, colourless, with a slight yellow-green tint (*Fig. 6: 11*) (*Smirnov 1941*, 166). Similar Central Asian vessels known in Nysa, Merv and Hauz-Han date to the 12th century (*Charyeva 1979*, 92, fig. 2: 8), in Transcaucasia – in Dvin, Kabala, Shemakha of the 9th century to the beginning of the 13th century (*Dzhiddi 1981*, 67).

3.5. Flacons and bottles for decantation

Special-purpose vessels for decantation and draining fluid off the settled sediment were designed to facilitate

[5] Bilyar Museum, BXXVIII/6858.
[6] Bilyar Museum, BXXII/11084.
[7] State Historical Museum, no. 77070, inv. 687; no. 77908, inv. 2189.
[8] State Historical Museum, no. 77908, inv. 2189, no. 31485.

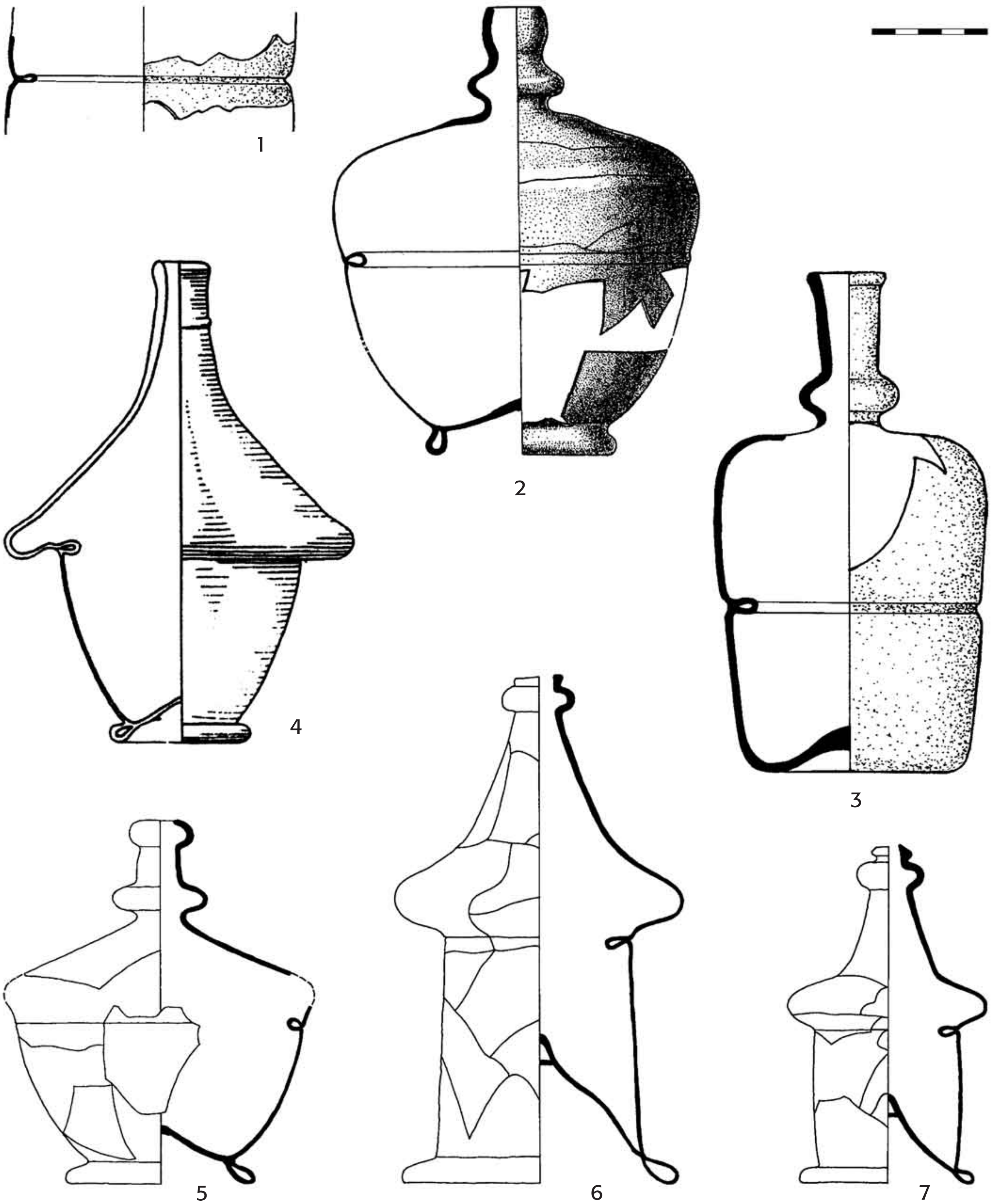

Fig. 7. *Vessels for decantation:* ***1*** *– Suvar ГИМ, #77908, op. 2189, #1495 (A. P. Smirnov excavations 1935 biennium);* ***2*** *– Novogrudok (after F. D. Gurevich 1981, 65, Fig. 50: 2);* ***3*** *– Dvin (after R. M. Dzhanpolyadyan 1974, 140);* ***4*** *– Germany (after C. Prohaska-Gross 1992, 93–94, Abb. 115, 116);* ***5–7*** *– Bratislava (after H. Sedláčková et al. 2014, Figs. 6: 1; 9: 21, 20). —* ***Obr. 7.*** *Nádoby k dekantaci.* ***1*** *– Suvar ГИМ, #77908, op. 2189, #1495 (A. P. Smirnov: výzkum biennium 1935);* ***2*** *– Novogrudok (podle F. D. Gurevich 1981, 65, Fig. 50: 2);* ***3*** *– Dvin (podle R. M. Dzhanpolyadyan 1974, 140);* ***4*** *– Německo (podle C. Prohaska-Gross 1992, 93–94, Abb. 115, 116);* ***5–7*** *– Bratislava (podle H. Sedláčková et al. 2014, Figs. 6: 1; 9: 21, 20).*

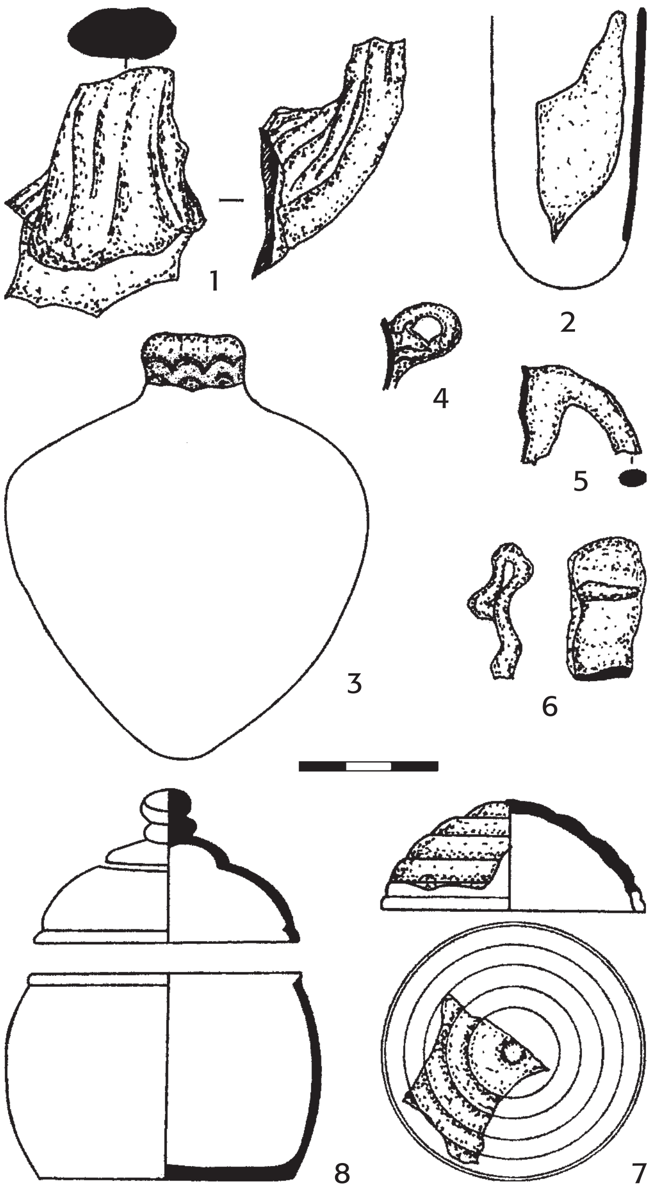

Fig. 8. Fragments of glass vessels of different classes: ***1, 4–6*** *– vessel handles БМ, ВХХII/18128, 18127, 19118; БХХIII/4154;* ***2*** *– test tube (БМ, ХХVIII/6858);* ***3*** *– sphero-conical vessel (БМ, ХХII/11084);* ***7*** *– vessel lid.* ***1–7*** *– Bilyar;* ***7*** *– ВМ, БХХVIII/3543).* ***8*** *– toilette box or sugar bowl from Buda Castle (K. Gyürky 1982, Abb. 1–2; Holl K. Gyürky 1986, Fig. 17). Drawn by T. Valiulin. —* ***Obr. 8.*** *Fragmenty různých druhů skleněných nádob:* ***1, 4–6*** *– ucha nádob;* ***2*** *– zkumavka;* ***3*** *– srdcovitá nádoba;* ***7*** *– poklička/víčko nádoby.* ***1–7*** *– Bilär;* ***8*** *– toaletní schránka nebo cukřenka z hradu v Budě (K. Gyürky 1982, Abb. 1–2; Holl K. Gyürky 1986, Fig. 17). Drawn by T. Valiulin.*

the process – their bodies had a small crosswise fold in the middle, bent from the outside to the inside across the whole circumference. Vessels with inner flange-folds are known in Syria from the 4th–5th centuries AD (*Stern 1977*, pl. 9, 27: A, B; *2001*, 252, cat. no. 138).

A fragment of a flacon body[9] was found in Suvar (D = 14 cm, width of flange-fold – 8 mm, wall thickness – less than 1 mm). The glass is transparent, pure, colourless, with a slight yellow-green tint (*Fig. 7: 1*). Similar special flacons are known in 10th-century Nishapur (*Kröger 1995*, 109, no. 154, 155), Dvin (*Dzhanpolyadyan 1974*, 140) (*Fig. 7: 3*), Novogrudok (*Gurevich 1981*, 65) (*Fig. 7: 2*) and 12th-century Misrian (Archaeological museum of the Institute of History of the Academy of Sciences of Turkmenistan 1979/M., p-2/180; *Mirzaakhmedov 2011*, 107, fig. 8). Flacons with the inner crosswise flange-fold emerged as pharmaceutical or alchemic vessels in antiquity; they are also known from the Byzantine Empire.

In the 13th–16th century in Germany, the Czech lands, Hungary and the Balkans, decantation functions were performed with biconical vessels (doppelkonische Flasche), with an inner crosswise flange-fold (*Fig. 7: 4–7*). Such vessels were used by alchemists, pharmacists and wine-makers (*Prohaska-Gross 1992*, 93–94, Abb. 115, 116; *Han 1975*, 122–123, fig. 9, 10; *Holl-Gyürky 1986*, 72, fig. 3: 3; 6: 2; *Bikic 2006*, 203–204, fig. 4: 2; 5: 10; *Beutmann 2014*, 156, Abb. 4, 6; *Sedláčková 2006*, 196, fig. 3.2, 3.3, 198, fig. 3b, 200, fig. 4.3, 206, fig. 5.8; *Sedláčková et al. 2014*, 224–225, 231, fig. 6: 1, 3–6; 9; 10; 11: 11).

3.6. Chemical glassware – Analytical methods and composition

The morphological and stylistic characteristics of the products are accompanied by data on the chemical composition of the glass. The chemical composition was determined using X-ray analysis (analysts: B. Gareev, G. Batalin) and scanning electron microscopy (analyst: A. Trifonov). Studies were carried out on a Merlin autoemission scanning electron microscope. The microscope is combined with an INCA X-MAX energy dispersive spectrometer. The resolution of the spectrometer is 127 eV. The detection limit is 1500–2000 ppm, with measurement accuracy of 0.01–1 %, depending on the state of the investigated artefact. The shooting of the surface morphology was carried out at an accelerating voltage of 5 keV to increase the depth of the field image. The analysis was performed at an accelerating voltage of 20 keV and a working interval of 9 mm to avoid minimal errors. Probing depth is less than 1 micron (*Table 1–2*).

With its chemical composition, Bilyar glassware relates to the largest group of glass products from the Bilyar settlement – 72.3 % of all glass items obtained at the site (*Valiulina 2005*, 76). The given group is represented by the ashen alkaline glass of the type Na-K-Ca-Mg-Al-Si (+Mn +Fe) (*Tab. 1: 1–10*; *Fig. 24A–D*). The latter glass type was widely used in the Middle Ages, especially in Islamic glassmaking, including sub-types preconditioned mainly by the geological, biological and chemical peculiarities of the *in situ* resources of different regions.

Similar to all Islamic glassware, Bilyar items are characterized by a low concentration of sodium compounds (more than 11.5 %) and a higher (compared to Central Asian products) percentage of potassium oxide (an average of about 5.5 %). The concentration of manganese oxide, another distinctive key component of products from both regions, reaches up to 1.8 % in Bilyar samples (*Tab. 1: 1, 2, 4–9*; *Fig. 24A–C*), whereas

[9] State Historical Museum, no. 77908, inv. 2189, no. 1495.

№	Sample \ Elements	Na_2O	MgO	Al_2O_3	SiO_2	P_2O_5	SO_3	Cr_2O_3	K_2O	CaO	TiO_2	MnO
1	АКУ285/4243	9.64	1.86	3.13	65.91	0.74	0.26	–	7.69	6.08	0.43	1.74
2	АКУ285/4739	12.77	2.44	3.58	63.26	0.99	0.23	–	6.52	5.83	0.33	1.13
3	АКУ285/2267	12.98	3.81	4.14	62.92	0.47	0.27	0.13	4.04	8.74	0.25	–
4	АКУ285/11A	11.9	2.43	2.83	65.15	0.21	0.4	–	4.65	8.11	0.43	1.55
5	АКУ285/4744	11.37	2.13	3.58	68.52	0.65	0.33	–	5.4	4.12	0.21	1.8
6	АКУ285/31	11.27	2.67	2.37	68.57	0.43	0.22	–	4.08	7.66	0.2	0.84
7	АКУ285/35	12.21	2.74	2.89	67.79	0.43	0.34	–	3.72	7.24	0.21	0.67
8	АКУ285/12A	13.97	2.58	3.86	6.55	0.75	0.28	–	5.37	4.2	0.23	0.74
9	АКУ285/4744A	11.32	2.11	3.02	68.71	0.63	0.35	–	6.22	4.55	0.14	1.61
10	АКУ285/4740	9.36	2.89	3.93	62.44	0.45	0.34	–	5.73	11.9	0.31	0.18

№	Sample \ Elements	FeO	NiO	As_2O_3	SrO	Sb_2O_3	Ag_2O	BaO	CuO	OsO_2	Hg	Total
1	АКУ285/4243	1.58	0.14	0.08	0.28	0.16	–	–	–	–	0.15	99.7
2	АКУ285/4739	1.23	–	0.12	0.53	0.25	–	–	0.01	0.48	–	99.69
3	АКУ285/2267	0.98	–	0.09	0.3	0.24	0.11	–	–	–	0.13	99.48
4	АКУ285/11A	1.24	–	–	–	–	–	–	–	–	–	98.9
5	АКУ285/4744	1.12	–	0.18	–	–	–	0.16	–	–	–	99.57
6	АКУ285/31	1.15	–	–	–	–	–	–	–	–	–	99.46
7	АКУ285/35	1.19	–	0.01	–	–	–	0.04	–	–	–	99.48
8	АКУ285/12A	1.21	–	–	–	–	–	–	–	–	–	99.68
9	АКУ285/4744A	0.95	–	0.02	–	–	–	0.11	–	–	–	99.74
10	АКУ285/4740	1.68	–	0.06	–	–	–	0.09	–	–	–	99.36

Table 1. *Chemical composition of glass alembic alchemy workshop from the Bilyar, excavation LXI. Results of spectral electron microscopy (SEM) analysis. —* ***Tab. 1.*** *Chemické složení skla alembiku z alchymistické dílny v Biläru, výzkum LXI. Výsledky analýzy provedené rastrovacím elektronovým mikroskopem (SEM).*

№	Sample \ Elements	Au	As	B	Ba	Be	Cd	Co	Cr	Cu	Ga	Mn	Mo	Nb	Ni	Pb	Sb	Sc
	Sensitivity	10^{-4}	10^{-2}	10^{-3}	10^{-2}	10^{-4}	10^{-2}	10^{-3}	10^{-3}	10^{-4}	10^{-3}	10^{-3}	10^{-3}	10^{-2}	10^{-3}	10^{-3}	10^{-1}	10^{-3}
1	metal alloy АКУ285/1045									20%						50%		
2	matrix АКУ285/116		0.14					0.1		86.03					0.073	0.15	0.05	
3	finger ring АКУ285/4678	90	1.05%	2.5		–	0.3	15	–	80.2%	–	2.8	8	–	10	8%	400	3
4	upper plate АКУ285/2264	200	–	2.5		–	0.3	–	–	5%	–	0.1	–	–	–	50	–	–
5	lower plate АКУ285/2264	–	10	2.5		–	0.3	–	–	63%	–	1	–	–	8	50	100	–

№	Sample \ Elements	Sn	Sr	Ti	V	Y	Yb	Zn	Zr	P	Ag	Ca	Fe	Al	K	Mg	Na	Si	Bi
	Sensitivity	10^{-3}	10^{-2}	10^{-1}	10^{-3}	10^{-3}	10^{-4}	10^{-2}	10^{-2}	10^{-1}	10^{-4}		%	%	%	%	%	%	1^{-3}
1	metal alloy АКУ285/1045	20%								3%	1%		2.5		2		1		–
2	matrix АКУ285/116	13.2						–			0.1	0.1							
3	finger ring АКУ285/4678	7%	–	0.1	–	–	–	–	–	15	200	–	2	0.05	–	0.03	–	2	
4	upper plate АКУ285/2264	3	–	–	–	–	–	35%	–	–	59.1%	–	0.01	–	–	0.01	–	0.8	
5	lower plate АКУ285/2264	25	–	0.1	–	–	–	–35%	–	–	100	–	0.01	0.04	–	0.02	–	1	

Table 2. *Results of X-ray fluorescent spectral analysis of certain metal items from Bilyar excavation LXI. —* ***Tab. 2.*** *Výsledky rentgeno-fluorescenční spektrální analýzy některých kovových předmětů z výzkumu LXI v Biläru.*

Central Asian glass (except for Uzgen and Hulbuk) is either totally or almost manganese-free (*Abdurazakov – Bezborodov — Zadneprovsky 1963*, tables 4–8). It is significant that two of the alembics found in Bilyar belong to Central Asian glass (*Table 1: 3, 10*; *Fig. 24D*); these patterns are different from the rest of Bilyar alembics and morphological characteristics: the shape and size (diameter – 5 cm, height – 6 cm) (*Fig. 4: 2*). Twelve such alembics were found in the house of the so-called Paikend pharmacist from the end of the 10th century – beginning of the 11th century (the Central Asian city of Paikend ceased to exist in the middle of the 12th century) (*Mukhametzhanov — Semyonov 1983*, 37–38).

Trace elements of certain Bilyar alembics contain a significant percentage of mercury (*Table 1: 1, 3*), which is especially important for determining the vessel's purpose.

A study of the specificity of raw materials of the Middle Volga and Cis-Uralian area offered an explanation for the peculiarity of the content of Bilyar glass (*Valiulina 2014b*, 280–284) of local production (Type Na-K-Ca-Mg-Al-Si /+Mn +Fe/). The glass in question is made of a triple bath (ash-lime-sand): alkaline raw material – ash of halophyte plants from the alkalized soils of the western trans-Kama region, alkali-earth raw material – dolomite limestone or dolomites of local origin, sand

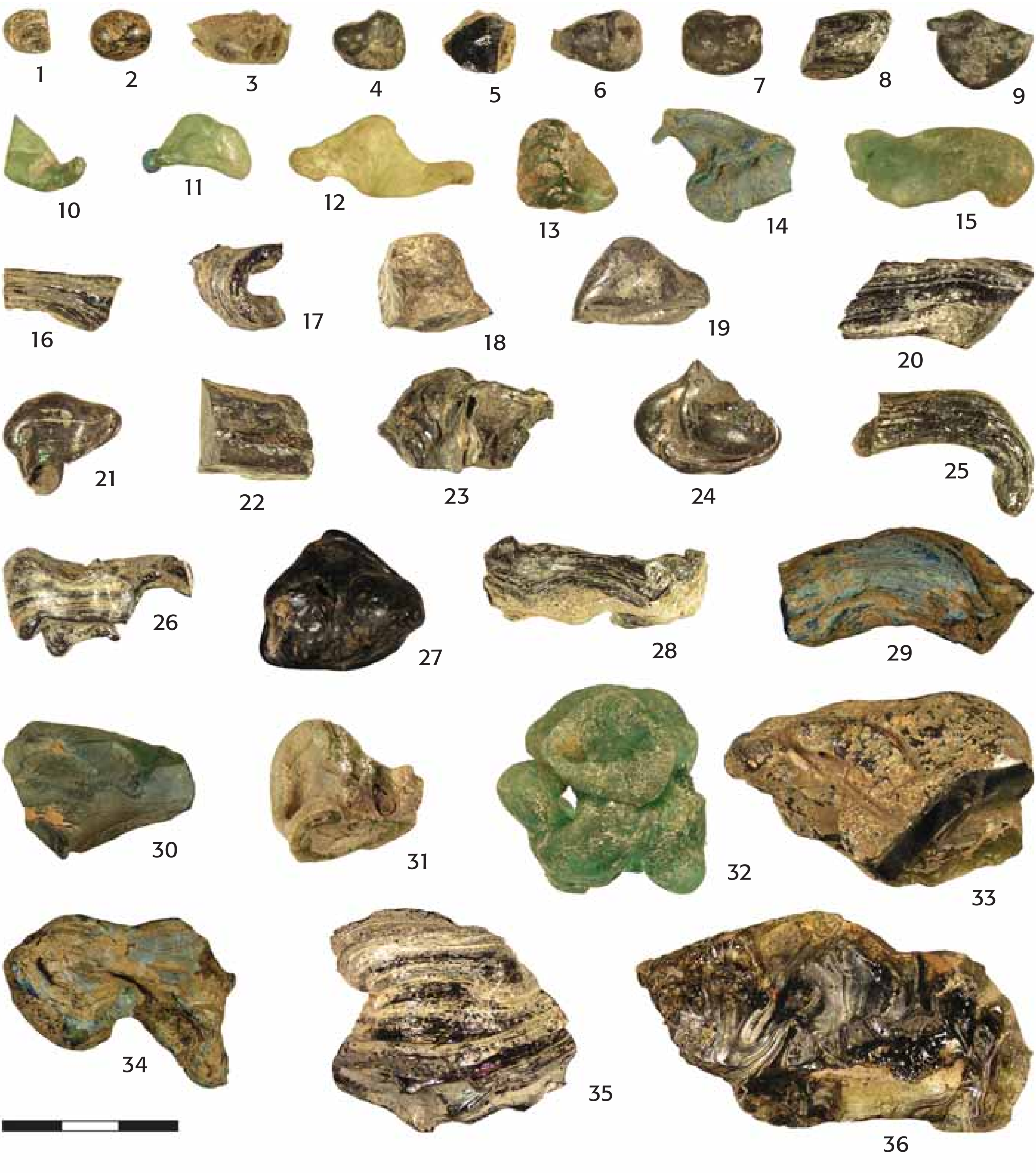

Fig. 9. *Glassmaking waste of: glass drops and shunk glass from A. Khalikov's Bilyar excavations XXXVIII biennium:* ***10, 18–25, 30, 31, 33–36*** *– БXXXVIII/1078–1098; and LXI:* ***1–9, 11, 17, 26–29, 32*** *– АКУ285/4684, 4591, 3127, 3103, 3128, 3108, 3109, 2388, 3105, 3110, 2385, 3092, 3090, 3093, 3091, 3175. Photo by T. Valiulin. —* ***Obr. 9.*** *Odpad z výroby skla: skleněné kapky a slitky skla z výzkumu A. Khalikova v Bilär (XXXVIII. biennium):* ***10, 18–25, 30, 31, 33–36*** *– a LXI:* ***1–9, 11, 17, 26–29, 32****. Foto T. Valiulin.*

from the Kama sand province rich in a high content of refractory fractions (chemical compounds of Fe, Ti, etc.), which deteriorate the quality of glass. Nevertheless, Bilyar glassware on the whole is of a high enough quality to meet both the technical and aesthetic standards in effect at the time. The high chemical durability of Bilyar glass is ensured by the optimal presence of basic components and aluminium oxide. There is no irisation, and patination is insignificant. Craftsmen succeeded with the adequate selection of local, i.e. cheap and easily

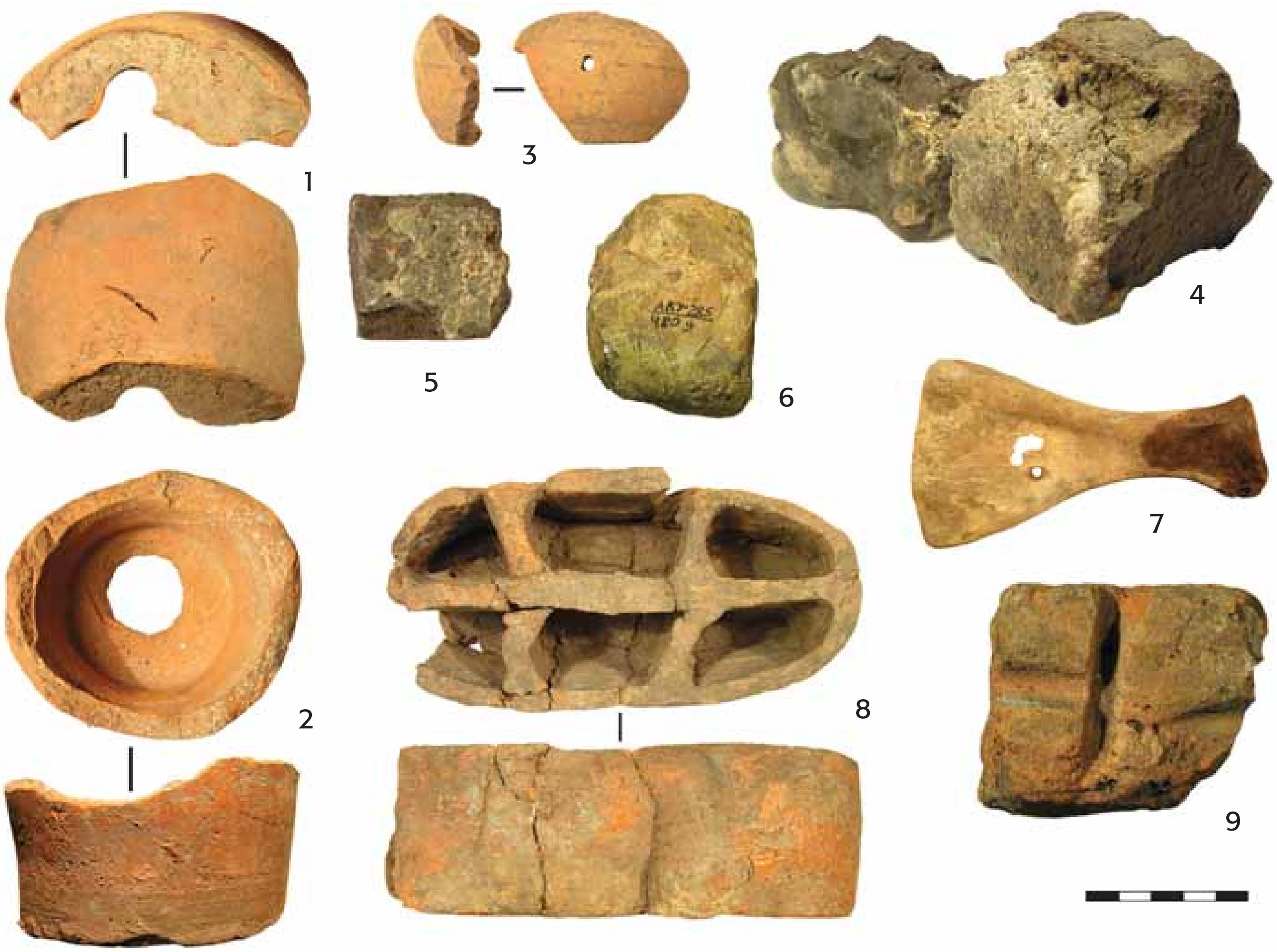

Fig. 10. *Various materials from the alchemy workshop (Bilyar excavation LXI):* ***1–3*** *– vessel fragments АКУ285/4915. 2688, 4691;* ***4, 5*** *– refractories АКУ285/4712, 4700;* ***6*** *– plug АКУ285/4809;* ***7*** *– spatula АКУ285/4688;* ***8*** *– box АКУ262/26;* ***9*** *– feather-edged brick with marking АКУ285/2190;* ***10, 11*** *– kiln daub АКУ285/2204, 3968.* ***1–3, 6, 8–9*** *– clay;* ***4, 5*** *– Dinas;* ***7*** *– bone. Photo by T. Valiulin. —* ***Obr. 10.*** *Zlomky technické keramiky a předmět z kostí z alchymistické dílny (Bilär: výzkum LXI):* ***1–3*** *– fragmenty nádob;* ***4, 5*** *– zlomky šamotových cihel;* ***6*** *– klínek;* ***7*** *– kostěná špachtle;* ***8*** *– schránka;* ***9*** *– cihla s břitem se značkou;* ***10, 11*** *– mazanice z pece.* ***1–3, 6, 8–9*** *– hlína/jíl;* ***4, 5*** *– z Dinasu;* ***7*** *– kost. Foto T. Valiulin.*

available, raw materials. Bilyar glassmaking should be considered as an integral part of the Middle East tradition. Handicraft practices developed in the course of the 12th century under the influence of Transcaucasian and, possibly, Central Asian schools. Being analogous by all parameters to samples from the above-mentioned centres of glassmaking, Bilyar glassware, apart from the original ratio of alkalis (Na-K compounds) and a significant presence of aluminium, is also characterized by a stable content of Fe and Mn compounds. Along with other features, the latter two elements stand out as distinctive indicators of Bilyar glassware (*Valiulina 2005*).

Apart from finished glass products, we obtained shunk glass, drawn glass drops and threads (*Fig. 9: 1–9, 11, 13, 17, 26–29, 32*), a semi-finished glass piece, a fragment of the massive bottom of a ceramic vessel with unworked liquid glass melt.

Alchemists could satisfy the need for glassware by manufacturing it on-site from semi-finished products (as practiced often by modern chemical laboratories). One may find relevant accounts in medieval manuscripts of Armenian alchemists. In other words, workshop craftsmen practiced a semi-complete manufacturing cycle.

4. Material proof of jewellery and alchemy practices

Some alchemy operations assumed the use of glass scrap and powder. In the chapter dedicated to the colouring of yellow copper in gold, in the section 'Description of interesting operations one can perform while near the kiln', ar Razi instructs as follows: 'Grind glass scrap in rosewater and mix it with some tincal used by coppersmiths. Then set layers of thick glass onto the bottom of the crucible, add [powdered] glass and tincal, yellow copper (the darkest known), then [powdered] glass and tincal, and cover everything with thick glass. Then blow under the crucible until [everything in it] is well-melted and set in circumrotation,

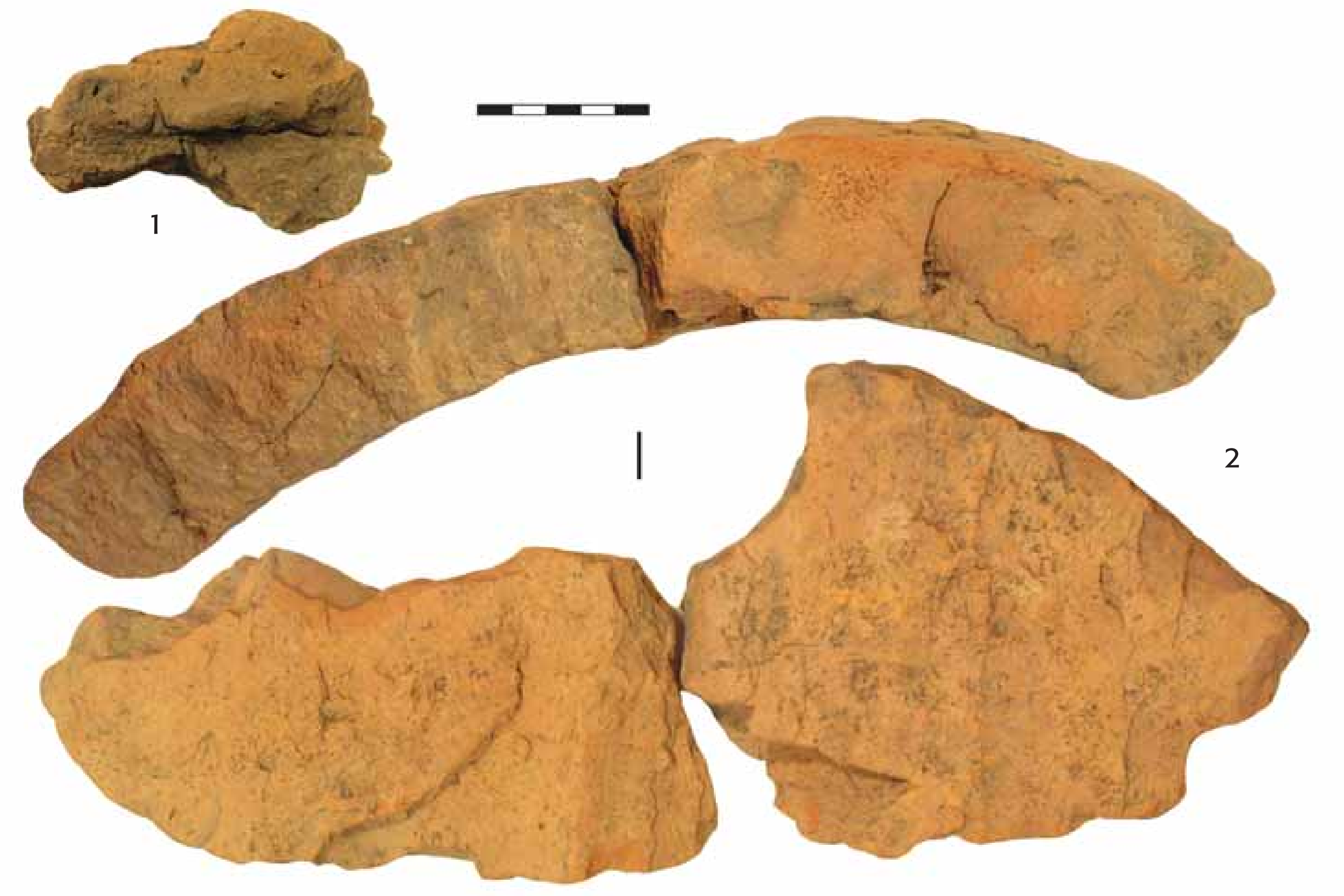

Fig. 11. Various materials from the alchemy workshop (Bilyar excavation LXI): 1–2 – kiln daub AKУ285/2204, 3968. Photo by T. Valiulin. — Obr. 11. 1–2 – zlomky mazanicového výmazu pece AKУ285/2204, 3968. Foto T. Valiulin.

then take the crucible away [from the fire] and cool [it] down, take out the ingot reminiscent of gold in terms of yellowness, appearance and glow. I have sold it to a goldsmith, splitting miskal into four kirats, I have sold one miskal in Bagdad for approximately ⅔ of a dinar (*Karimov 1957*, 86). The use of glass is also recommended in other chapters of *The Book of the Secret of Secrets*: for the calcination of glass (*Karimov 1957*, 95), for distillation of mercury and synthesis of amalgam (*Karimov 1957*, 98; 119, note 25; 155, note 348).

Glass in the workshop of an alchemist, jeweller and glassmaker could also be used in a different fashion. Drawing on earlier sources, M. Chapman suggests that in the 18th century, in order to strengthen the colour of gold plating of bronze products, ancient craftsmen used ammonia, saltpeter, verdigris and other substances, including glass (*Chapman 1995*, 235). Aside from that, the presence in alloys of nonferrous metals of such admixtures as tin and zinc hindered the purification procedure. According to Theophilus, the problem was solved by adding a special flux – crushed glass (*Eniosova — Reren 2011*, 248). The cultural layer and the fill of all objects at the excavation are rich with ash, coal, brick rubble, pieces of sulphur, and handicraft production waste. Some glass vessels bear traces of mercury (*Valiulina 1998*, 90). Apart from iron balls and slag (*Fig. 13*), we also found numerous artefacts made of iron — fragments of different tools, locks, keys, nails, lead seals (*Fig. 19: 6, 7*), metal cubic scale weights (*Fig. 19: 1–5*), stone balance weights (*Fig. 19: 15*) similar to those in use in pre-Mongolian Baylakan (*Akhmedov 2003*, Tab. 193: 31) and whetstones (*Fig. 12: 2–3*). Numerous materials are related to jewellery practices of the workshop owners: moulds (*Fig. 17: 11–13*), grinding stones (*Fig. 12: 1, 5–8*) and slabs, massive slabs with a worn-out surface, sometimes bright-finished, touchstones (*Fig. 19: 8–14*), technical (*Fig. 10: 1–9; 11: 1–2; Fig. 17: 1–10*), household (*Fig. 14: 1–22*) and glazed ceramics (*Fig. 20: 1–9*), copper ingots and plates, lead-tin ingots (*Fig. 18: 13, 15*), tin splashes, a bronze monetary ingot soum (*Fig. 19: 16*), a fragment of golden foil, a silver earring (*Fig. 18: 5*), metal pincers (*Fig. 12: 4*), pieces of copper and fragments of copper and bronze items, including a braided bracelet (*Fig. 18: 6*), a finger ring (*Fig. 18: 1*), chevrons (*Fig. 18: 11–12*), binding from the rim of a wooden vessel (with charred wood preserved inside), several fragments belonging to the same metal vessel, a needle (*Fig. 18: 7*), two bell buttons (*Fig. 18: 4*), and other objects (*Fig. 18: 9, 10, 14*). A fragment of a bronze (brass?) product made of thin metal sheet was decorated with images of fish (*Fig. 18: 2*) using a matrix embossing technique.

The chemical composition of several metal items was determined by means of X-ray fluorescent spectral

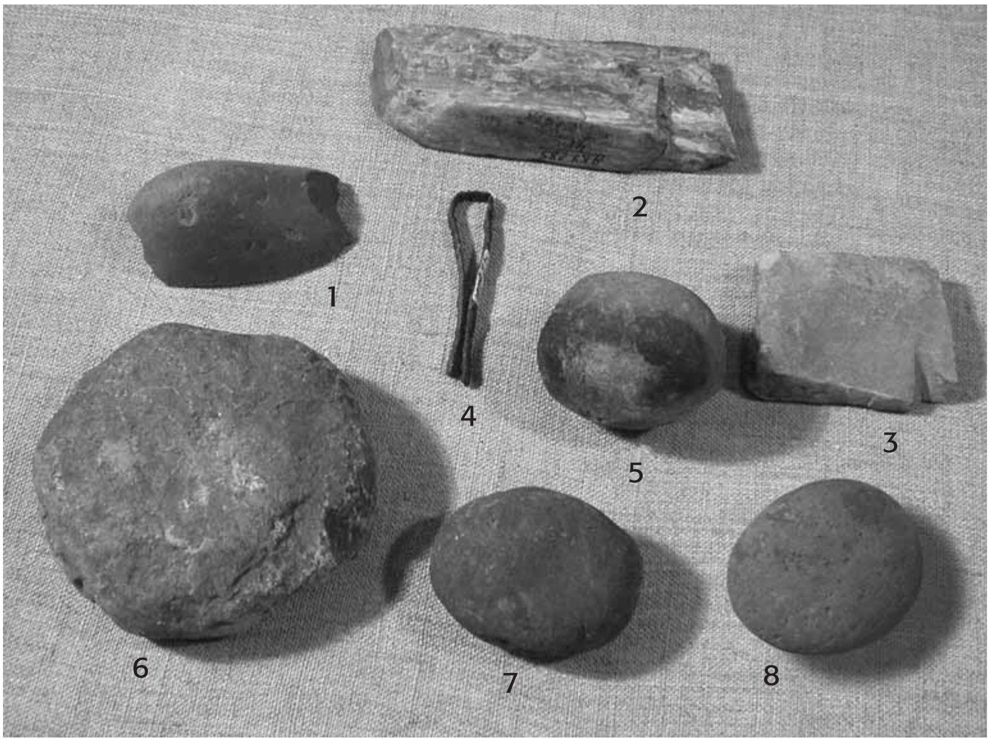

Fig. 12. *Various materials from the alchemy workshop (Bilyar excavation LXI):* ***1–3*** *– whetstones АКУ285/4699, 2632, 2250;* ***4*** *– metal pincers АКУ285/4571;* ***5–8*** *– grindstones АКУ285/4690, 2491, 4590, 4800. Photo by T. Valiulin. —* ***Obr. 12.*** *Nálezy z kamene a kovu z alchymistické dílny (Bilär: výzkum LXI):* ***1–3*** *– brousky;* ***4*** *– kovová pinzeta;* ***5–8*** *– brusné kameny. Foto T. Valiulin.*

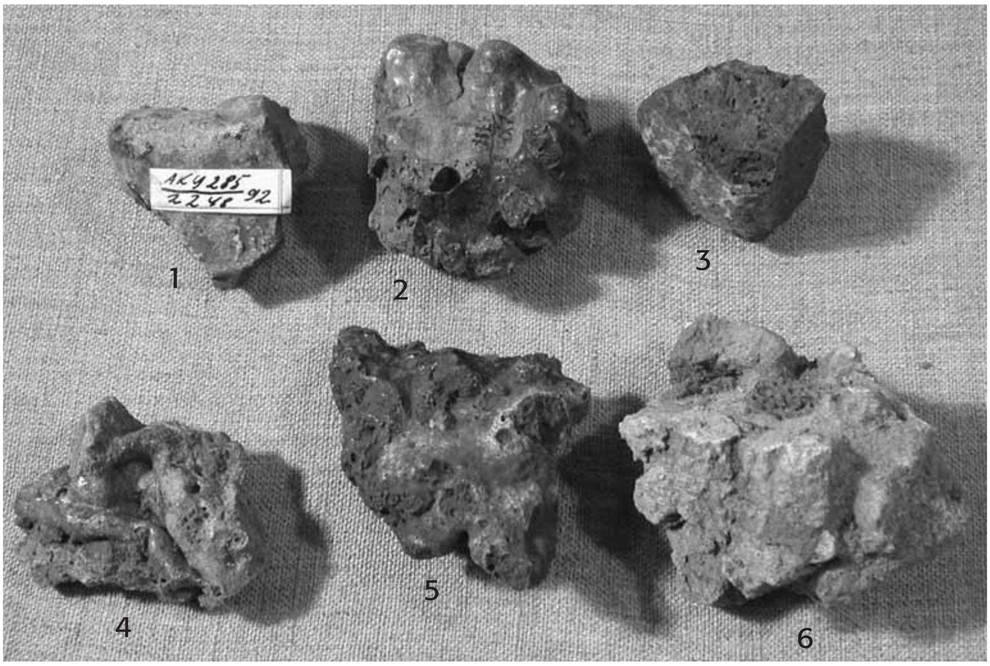

Fig. 13. *Fragments of refractories and slag from the alchemy workshop. Bilyar excavation LXI. АКУ285/ 2248, 3787, 2245, 2066, 4803, 4619. Photo by T. Valiulin. —* ***Obr. 13.*** *Fragmenty šamotu a strusky z alchymistické dílny. Bilär: výzkum LXI. Foto T. Valiulin.*

analysis. The first glossy maroon sample (*Tab. 2: 1*), one of the numerous finds of this sort from the excavation, is a lead- and tin-based alloy. The combination of the given two metals could be useful for many purposes, in particular, for the synthesis of amalgam (*Karimov 1957*, 117).

A second sample is a fragment of a product (presumably matrix) made of tin bronze (*Tab. 2: 2*), an alloy composition similar to Bulgar metal plates (*Khlebnikova 1988*, Tab. III, no. 27).

A third sample (*Tab. 2: 3*) is a cast 2.0 cm finger ring (*Fig. 18: 1*) with a round flat 1.3 cm ring face with carved Arabic symbols (illegible due to their poor quality) and geometric ornamentation. It is made of lead-tin bronze with a significant share of arsenic (1.5 %). The copper was probably alloyed with arsenic bronze. The majority of experts agree that arsenic alloys were usually synthesized by melting ore minerals, for example, copper oxidized ores, with arsenic sulphide ores – realgar (As_2S_2), orpiment (As_2S_3) and arsenic pyrite ($FeAsS$)

Fig. 14a. *Samples of pottery from the alchemy workshop:* ***1–8*** *– oil lamps АКУ285/2185, 2068, 2115, 2069, 2533, 2535, 2114, 2534;* ***9–11*** *– cups АКУ285/4899, 4049, 2700;* ***12–15*** *– tripods АКУ285/4851, 4819, 199, 4913; 2532, 4929;* ***16–21*** *– fragments of vessels with signs АКУ285/4913, 2210; 4931, 2191, 4918, 4899;* ***22*** *– pitcher with a sign АКУ285/2180. Photo by T. Valiulin. —* ***Obr. 14a.*** *Ukázky hrnčířského zboží z alchymistické dílny:* ***1–8*** *– olejové lampičky;* ***9–11*** *– misky;* ***12–15*** *– trojnožky;* ***16–21*** *– fragmenty nádob se značkami;* ***22*** *– džbán. Foto by T. Valiulin.*

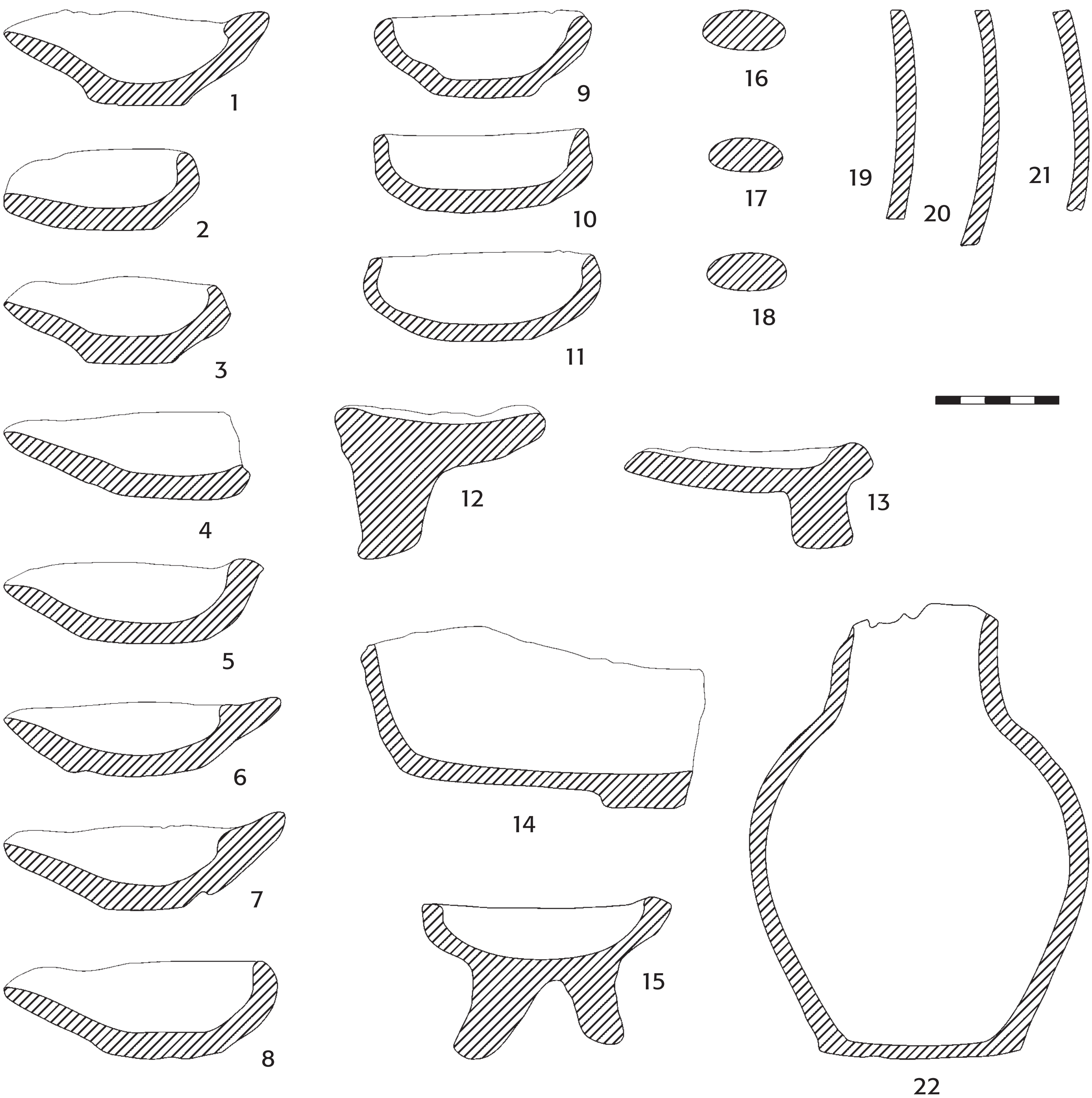

Fig. 14b. *Profiles of samples from Fig. 14a. Drawn by T. Valiulin. —* ***Obr. 14b.*** *Řezy k obr. 14a. Kresba by T. Valiulin.*

(*Konkova 1989*, 34). Ar Razi uses the plural form of the word 'az-zarnikh' either as a common name for realgar and orpiment or names them 'yellow zarnikh' and 'red zarnikh', accordingly (*Karimov 1957*, 119).

Two samples characterize the composition of a twin-layer product – a rectangular chevron, or a plate (type B-II-1 in G. F. Polyakova's classification) (*Polyakova 1996*, 195, fig. 65: 8) with an embossed symmetrical floral ornament (*Fig. 18: 3*). Experts recognize a large number of both items and matrices for their ornamentation obtained at Bulgar sites as positive proof of their local origin (*Polyakova 1996*, 197; *Halikov /ed./ 1985*, 100, fig. XXXVII: 10–14). A considerable number of such chevrons originate from the Bilyar settlement. However, coupled samples bearing edge-fastened bronze and silver plates are very rare. Excavation XXXVIII in Bilyar yielded yet another sample, the very thin upper (face) plate of which is made of silver added to or alloyed with copper and zinc (*Tab. 2: 4*). The alloy also contains some gold. Silver, zinc and copper become mutually soluble at 700–710°C. Shares of 60 % silver and 35 % zinc ensure the preservation of the best qualities of silver – the pure 'silver' colour, brightness and shine. The medieval craftsman succeeded in his search for the optimal (marginally acceptable, by standards of modern metallurgy) formula.

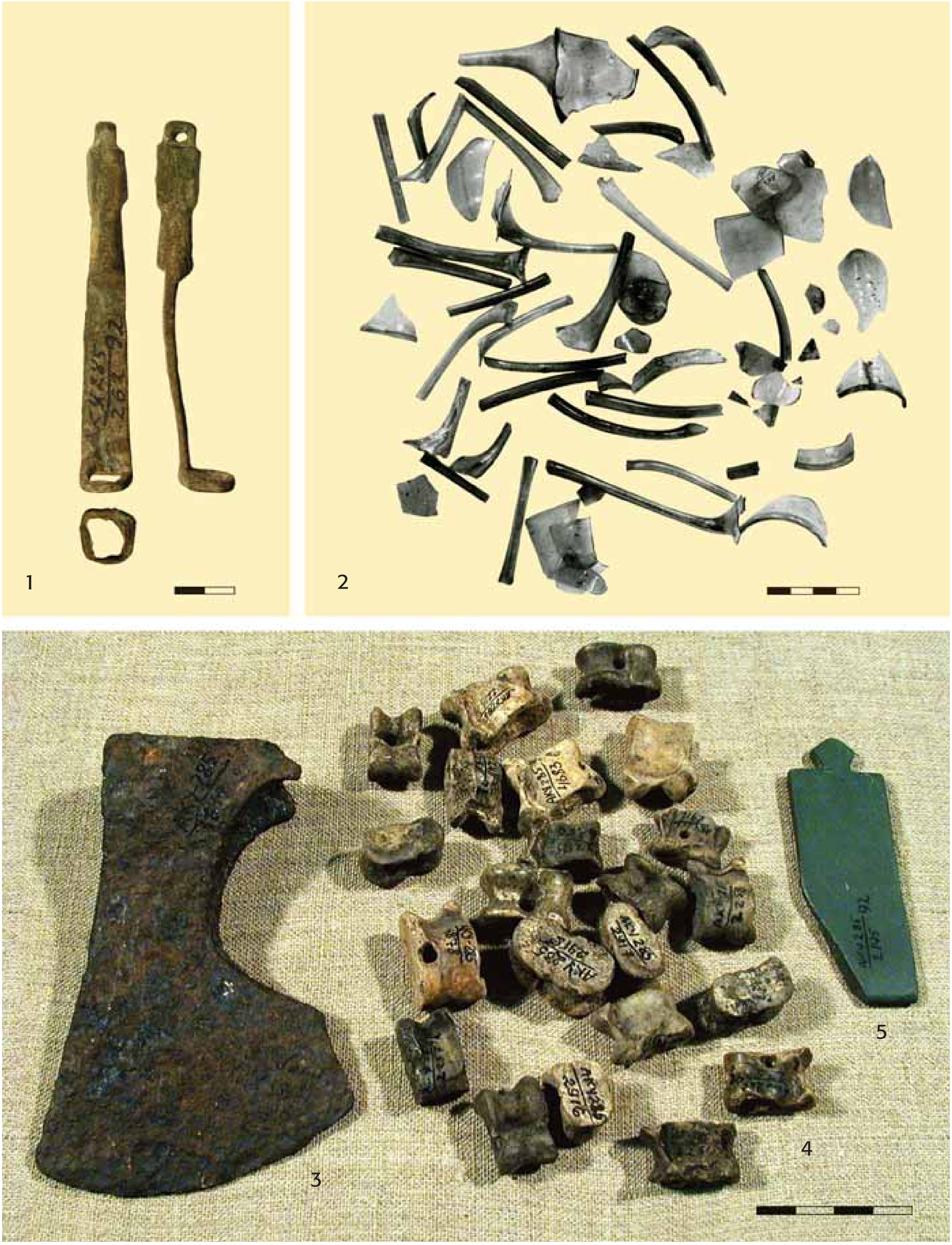

Fig. 15. *Items from the hoard of alembics. Bilyar excavation LXI, pit 9a:* ***1*** *– АКУ285/2262;* ***2*** *– АКУ285/30-43, 2267, 2268, 2269, 4740, 4744;* ***3*** *– АКУ285/2246;* ***4*** *– АКУ285/4683, 2215, 2821, 2912, 2258, 4878, 2915, 2917, 2916, 2257;* ***5*** *– АКУ285/2195. Photo by T. Valiulin. —* ***Obr. 15.*** *Předměty z depotu alembiků. Výzkum LXI v Biläru, jáma 9a:* ***1*** *– bronzový klíč;* ***2*** *– zlomky alembiků;* ***3*** *– železná sekera;* ***4*** *– astrogály z ovčích kostí (27 kusů);* ***5*** *– antropomorfní předmět – amulet ze zelené břidlice znázorňující postavu pohanského boha Tengri Turci. Foto T. Valiulin.*

Fig. 16. *Sphero-conical vessels and alembic from the alchemy workshop. —* ***Obr. 16.*** *Nádoby srdčitého tvaru a alembik z alchymistické dílny.*
1 *– alembic АКУ285/4739;*
2, 6 *– sphero-conical vessels АКУ285/2018;*
3, 4 *– АКУ285/2951;*
5 *– АКУ285/2483;*
7 *– АКУ285/2224.*
Photo/Foto by T. Valiulin.

The given ceiling percentage of zinc still maintains the single-phase α-structure of the alloy, whereas 40 % entails the formation of a β-structure with the subsequent deterioration of physical properties leading, above all, to increased fragility (*Hansen — Anderko 1962*, 78–79). The 60/35 formula is excellent in terms of both the technology itself and the final result, representing one of the numerous examples of the victory of experiment-based intuition centuries before theoretical computations and the involvement of unnamed craftsmen in the discovery of the nature of alloy transformations.

The lower plate is to some extent a mirror reflection of the silver plate (*Tab. 2: 5*).


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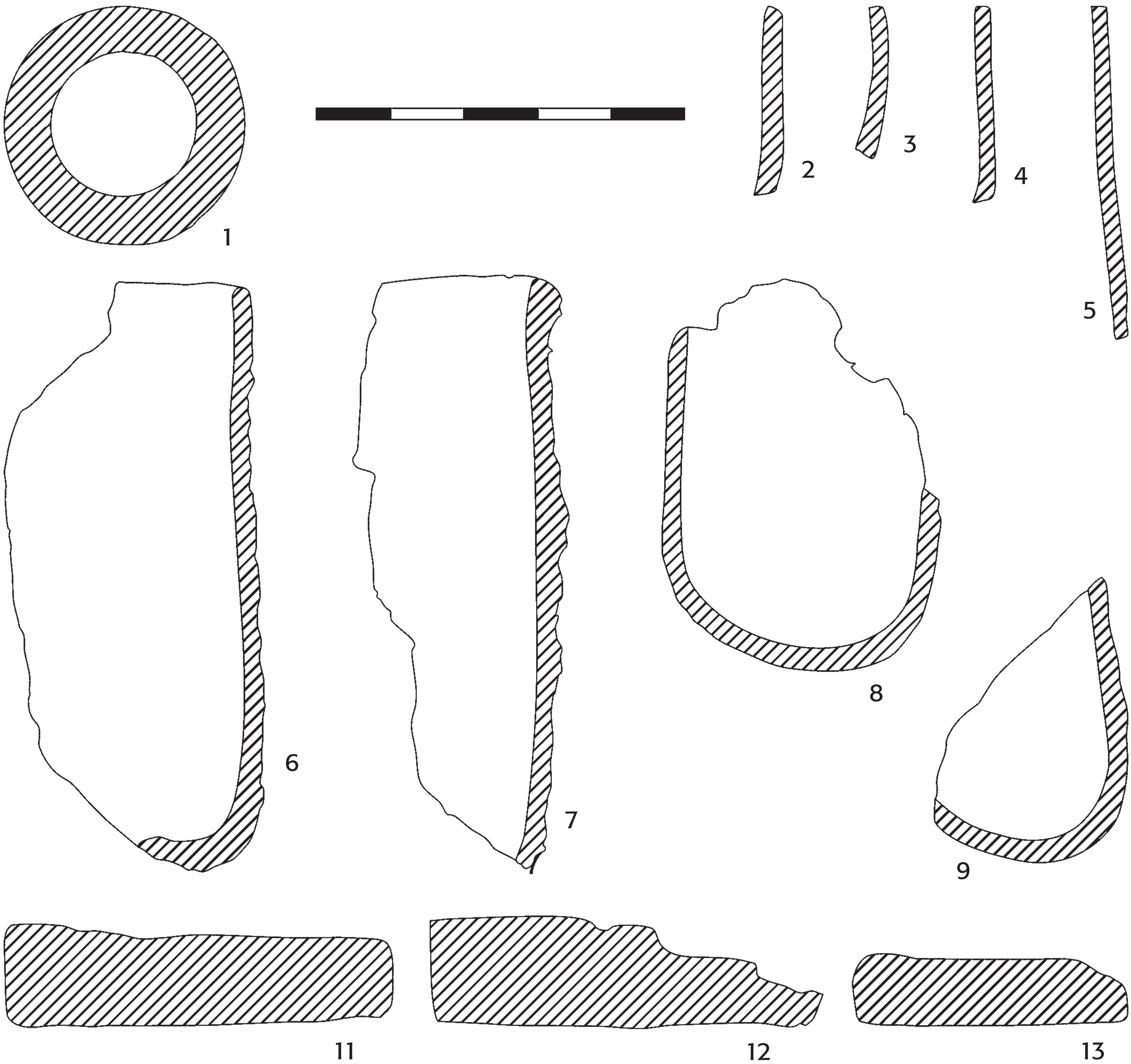

Fig. 17b. Items from the alchemy workshop. Bilyar excavation LXI. Profiles from Fig. 17a. Drawn by T. Valiulin. — Obr. 17b. Zlomky technické keramiky a předměty z kamene z alchymistické dílny. Výzkum LXI v Biläru. Profily předmětů z obr. 17a. Kresba T. Valiulin.

The given copper-based high brass alloy has the same percentage of zinc, whereas silver is just a trace element. A scale pan from Bulgar is made of a similar alloy (*Khlebnikova 1996*, Tab. III, no. 39, 269–282). For yellow copper or brass made of ⅔ copper and ⅓ zinc, Ar Razi used the Arab word 'ash-shabah.'

A number of trace elements accompanying copper in the alloy of the fourth sample – manganese, stibium, arsenic, silver, tin, aluminium – can be considered to be of geochemical origin. Both tests (*Tab. 2: 4, 5*) indicated an equally insignificant percentage of lead. Obviously, lead strongly correlates with zinc, being its geochemical ore companion.

The fourth and fifth samples are notable for a low content of trace elements. This could be due to the extensive purification of copper and the use of pure car-

Fig. 17a. *Items from the alchemy workshop. Bilyar excavation LXI:* ***1*** *– muzzle AKY285/3923;* ***2–9*** *– crucibles AKY285/4154, 2218, 2219, 2229, 2230, 2233, 2234, 2263;* ***10*** *– clay daub of sphero-conical vessel AKY285/4800;* ***11–13*** *– stone foundry moulds AKY285/23, 32, 4831. Photo by T. Valiulin. —* ***Obr. 17a.*** *Zlomky technické keramiky a předměty z kamene z alchymistické dílny. Výzkum LXI v Biläru:* ***1*** *– dyzna;* ***2–9*** *– tyglíky;* ***10*** *– mazanice;* ***11–13*** *– formy na odlévání. Foto T. Valiulin.*


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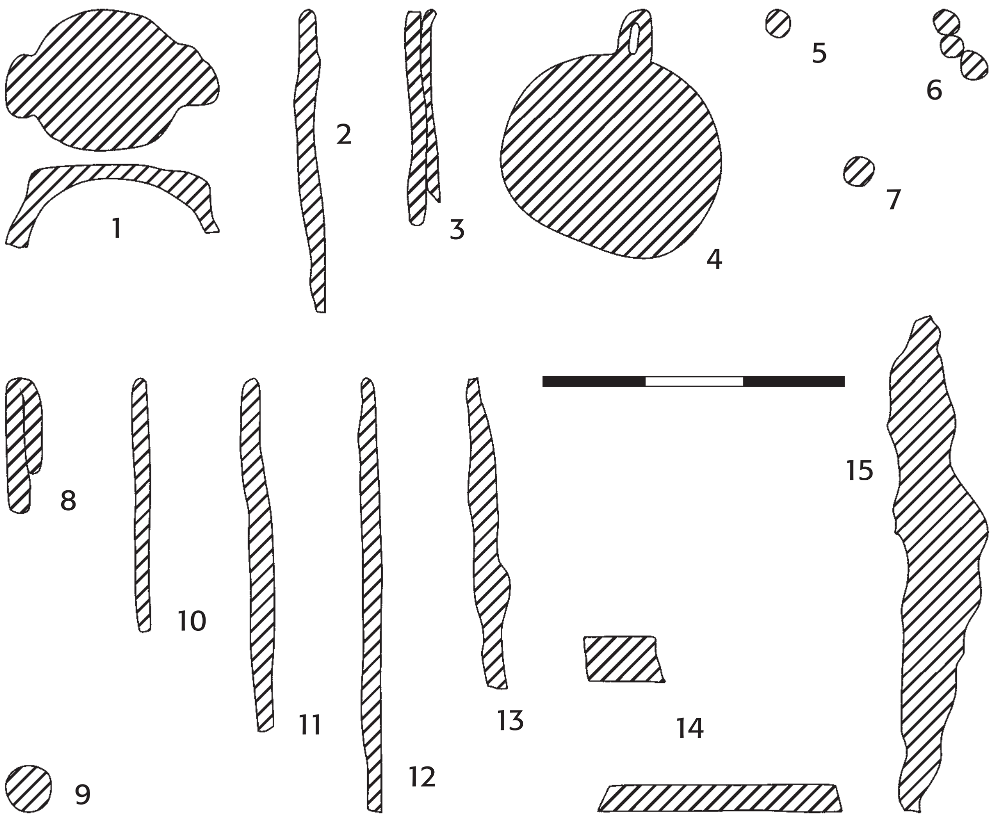
Fig. 18b. Nonferrous items from the alchemy workshop. Bilyar excavation LXI. Profiles from Fig. 18a. Drawn by T. Valiulin. — ***Obr. 18b.*** *Neželezné předměty z alchymistické dílny. Výzkum LXI v Biläru. Profily z obr. 18a. Kresba T. Valiulin.*



bonated zinc ore or zinc metal. If the latter 'is synthesized by way of deoxidization, it separates from the reaction mix, thus brass melted from such zinc is distilled' (*Egorkov — Scheglova 2001*, 288).

Pit no. 18 in the northwest section of excavation XLI yielded a clay bowl filled with 1.116 kg of apparently fired (mainly red) raw amber (*Fig. 22: 2*) found inside a ruined kiln at a depth of 115 cm. The given find can hardly be associated with chemical practices and iatrochemistry in the pre-Mongolian era. In fact, Andreas Libavius achieved succinic acid by means of the dry distillation of amber (*Djua 1966*, 69). By and large, unprocessed pieces and bits of amber, as well as finished amber artefacts, are not hard to find in Bilyar. Sometimes archaeologists discover much more valuable treasure troves. Most likely, the amber from excavation XLI was intended for ornamentation purposes in jewellery production (*Fig. 21: 9, 10, 13*).

The presence of other materials within the excavation perimeter is quite explainable. For example, lime was in demand by many handicraft industries. Deposits of lime are available across the entire territory of the excavation, more often near the kilns. Kiln no. 3 in the central part of the excavation neighbours pit no. 15 (175 × 120 cm) filled with lime to a depth of 137 cm. Judging from the pit's distinct carbon-bearing contour, lime was kept in a wooden box. The surface of massive slabs near the pit is worn out. Ancient alchemists' accounts of dead and live lime are so numerous that there is no point in citing them here.

Alchemists ascribed great significance to eggs in chapters about calcination and in many other cases. Leaving aside the philosophical world-view importance of the given substance in alchemy (especially in western alchemy), it is worth noting that in his recipes ar Razi makes 19 references to eggs, eggshell, egg whites and yolks (*Karimov 1957*, 183, 186, 188). Eggshells have been found at various sites, with excavation XLI yielding eight points of eggshell concentrations.

5. Touchstones and testing methods

Touchstones – small, black, plain, smooth-faced and oval-shaped kidney-stones, often perforated for hanging purposes – were the necessary tools of alchemists and jewellers. According to the results of a petrographic analysis, stones from the Bilyar workshop are pieces of siliceous schist composed of quartz (80 %), chlorite

Fig. 18a. *Nonferrous items from the alchemy workshop. Bilyar excavation LXI:* ***1*** *– ring АКУ285/4678;* ***2, 11, 12*** *– fragments lining АКУ285/4740, 2364, 4599;* ***3*** *– fragment of a two-layer lining АКУ285/2264;* ***4*** *– bell АКУ285/4673;* ***5*** *– earring (Silver) АКУ285/4719;* ***6*** *– twisted bracelet АКУ285/4742;* ***7, 9*** *– needle АКУ285/2095, 4614;* ***8*** *– forged edge of the vessel АКУ285/4622;* ***10, 14*** *– handle vessels АКУ285/4721, 2361;* ***13, 15*** *– copper ingots АКУ285/4745, 2275a. Photo by T. Valiulin. —* ***Obr. 18a.*** *Předměty z barevných kovů a stříbra z alchymistické dílny. Výzkum LXI v Biläru:* ***1*** *– prsten;* ***2, 11, 12*** *– fragmenty intarzií;* ***3*** *– fragment dvouvrstvé intarzie;* ***4*** *– zvonek;* ***5*** *– náušnice (stříbro);* ***6*** *– náramek splétaný ze tří pramenů drátu;* ***7, 9*** *– jehla;* ***8*** *– kovový lem nádoby;* ***10, 14*** *– ucha nádob;* ***13, 15*** *– měděné ingoty. Foto T. Valiulin.*

*Fig. 19a. Items from the alchemy workshop (Bilyar excavation LXI): **1–5** – metal weights АКУ285/4597, 4598, 4361, 2362, 4699; **6, 7** – lead seals АКУ285/2363, 2363а; **8–14** – touchstones АКУ285/2250, 2250а, 2131, 2161, 2239, 2430, 2480, 1871; **11** – АКУ285/2161, **15** – set of stone weights АКУ285/4592, **16** – money ingot – bronze soum АКУ285/1511. Photo by T. Valiulin. — **Obr. 19a.** Předměty z kovů a kamene z alchymistické dílny (výzkum LXI v Biläru): **1–5** – kovová závaží; **6, 7** – olověné plomby; **8–14** – prubířské kameny; **11** – АКУ285/2161; **15** – soubor kamenných závaží; **16** – bronzový mincovní ingot soum. Foto T. Valiulin.*

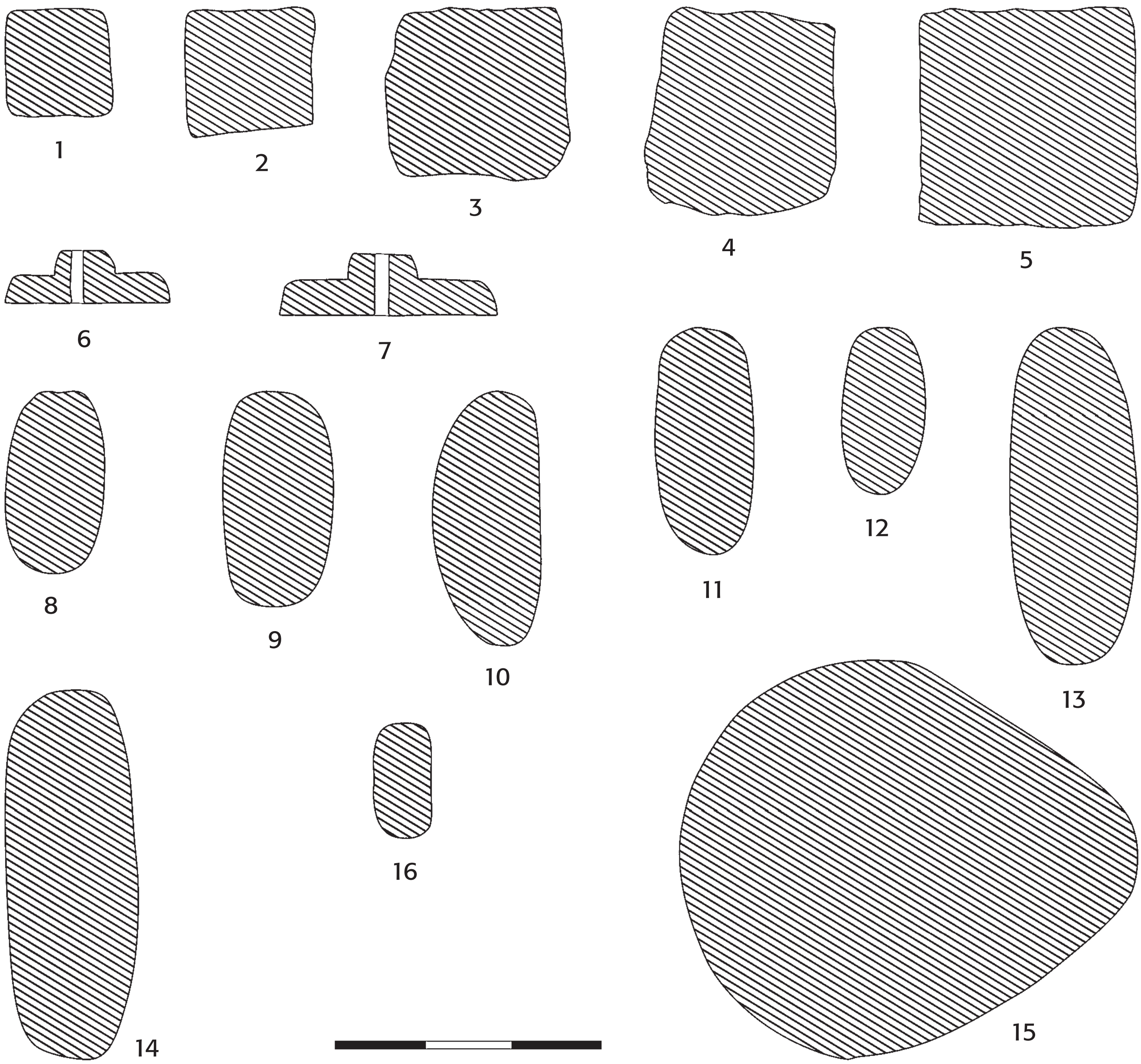


Fig. 19b. *Items from the alchemy workshop (Bilyar excavation LXI). Profiles from Fig. 19a. Drawn by T. Valiulin.* — ***Obr. 19b.*** *Předměty z alchymistické dílny (výzkum LXI v Biläru). Profily z obr. 19a. Kresba T. Valiulin.*

(10 %), calcium (5 %) and ore accessory minerals. Their probable place of origin is: 1) the 'Jasper Belt' of the Southern Urals; 2) the Caucasus. Location: seashore.[10]

Touchstones are held at many museum collections,[11] as they are artefacts frequently found at medieval sites, including excavations at the Bilyar settlement (XXVIII, XL). They are an integral part of materials obtained at the Golden Horde sites, including the Selitrennoe settlement (*Fyodorov-Davydov 1984*, ill. 95: 8, 9). One of the recent finds from the Bilyar area originates from the jewellery workshop of the Toretsk settlement from the end of the 14th century and the 15th century (*Valiulina 2004*, fig. 6: 21).

Touchstones from the alchemy workshop are not perforated (*Fig. 19: 8–14*). However, some of them bear traces of initial drilling. The wide plain surface of one of the touchstones bears several golden line-strokes arranged in a fanwise fashion[12] (*Fig. 19: 11*).

Since classical times, people have distinguished between pure gold, its alloys with other metals, and fake

[10] The petrographic analysis was performed by Professor V. G. Izotov, the head of the Department of Mineral Resources of Kazan State University, whose efforts I deeply appreciate.

[11] University Archaeological Collection 85/35; National Museum of Finland, 5385: 4006, 4007 – Bilyar; National Museum of Finland, inv. 5385: 5000, 5001 – Laishevo.

[12] University Archaeological Collection 285/2161.

gold. According to Pliny, Romans used touchstones for distinguishing different gold-based alloys (*Djua 1966*, 74). One of the earliest descriptions of the nature of touchstones was suggested by the ancient Greek philosopher-encyclopaedist Theophrastus (c. 371 – c. 287 BC) in his treatise *On Stones*: 'The nature of the touchstone is quite remarkable. It helps to determine the degree of gold purity, as it seems to possess the property of fire, which is also used to determine the purity of gold. On this occasion many people hesitate, though without justification, as stone tests gold in a different way. The impact of fire entails a change in colour, whereas stone deploys friction in a way that it seems to be capable of identifying the true nature of every metal… Touchstones are used not only to determine the purity of gold, but also the share of gold and silver in alloys, and the share of impurities in each stater, however insignificant such impurities might be' (*Theophrastus* /*Kulikov 2004*, 55/).

E. Caley and J. Richards, in their comments on Theophrastus' text, refer to the results of the determination of gold content in the alloys of silver and gold by Japanese jewellers. The difference between touchstone test results and results obtained from modern methods is only 1 %. This is possible when the gold content in the alloy varies within the range of 70–80 % (*Theophrastus* /*Kulikov 2004*, 152/). According to Theophrastus, all touchstones were obtained from a single source: the basin of the river near Tmolus Mountain.[13] Commentators on Theophrastus' treatise point at an array of historical evidence proving that Tmolus Mountain was an important gold-mining centre in the second half of the first millennium B.C. Touchstone tests were probably introduced by miners; all the more so, because Tmolus gold was actually electrum, with a varying silver content (*Theophrastus* /*Kulikov 2004*, 154/).

Even today experts prefer touchstone tests to other methods, in the majority of cases. Here is how the given process is described in a modern jewellery-making guide: 'First of all, the touchstone's surface should be slightly greased with almond, nut, or other type of vegetable oil, and then it should be wiped dry. Then, with the same force of pressure, rub the gold alloy of unknown purity and a test needle (sample of gold alloy of known value) against the touchstone surface to leave streak-shaped metal samples. Swipe the applicator moistened with the relevant test solution across the samples for 20–30 seconds. While the test solution is carefully being dried, experts compare the results of its impact on samples. The intensity of the colour of the spot formed under the impact of the test solution is indicative of the content of gold in the alloy' (*Novikov — Pavlov 1991*, 190). The best results are achieved by using nitric acid and aqua regia – chemical compounds invented by Arab alchemists in the Middle Ages. *The Book of the Secret of Secrets* by ar Razi contains 16 recipes for different 'acidy waters'. Some of them are suitable for the preparation of mineral acids, including hydrochloric acid (*Karimov 1957*, 121, note 35). However, known sources lack any references as to the use of acids during touchstone tests. Apparently, in classical times touchstone tests were performed without the use of any chemical compounds.

[13] Ancient Tmolus Mountain (modern Bozdağ) in Lydia.

Works by medieval authors also contain mention of touchstones. Ar Razi writes about 'mihak' – a touchstone usually made of hard black stone. Al-Istahri refers to 'mepek' – a black stone used for the determination of the quality of gold shipped from Shabran to other parts of the world (*Akhmedov — Ibragimov 1976*, 29). With regard to the geographic location of Shabran in Transcaucasia on the shore of the Caspian Sea and the results of a petrographic analysis of the stone from the workshop of an alchemist in Bilyar, we can assume that the stone in question was imported from Transcaucasia.

The purity of gold used by Bilyar alchemists was established during routine testing of the items of the Golden Fund of the Archaeological Museum of Kazan University, using a touchstone (*Fig. 19: 11*). The analysis proved that the craftsman operated with '850' gold.

According to ar Razi, apart from other types of assay tests, ancient experts would check the quality of alloys by biting them with their teeth (*Karimov 1957*, 145, note 232).

In ancient times fire assay tests[14] of gold were used only for qualitative analysis. Long-term firing led to the oxidation of admixtures of base metals, whereas pure gold remained constant (*Karimov 1957*, 129, note 53). Chinese Taoist (*Gĕ Hóng Pao-p'u-tzu* /*Torchinov 2001*, 333/) and Armenian alchemists apparently used exactly this method, as one of the Matenadaran manuscripts (no. 8446, 37b) reads as follows: '…the bodies of metals are not absolutely refractory, as they gradually melt away while fired, except for pure gold, which does not disappear or shrink because of the fire, only getting better and finer instead' (*Kazandzhyan 1955*, 83).

6. Technical ceramics

Fragments of ceramic vessels ('assay sherds') obtained at excavations testify to fire assay tests practiced at the Oberstockstall alchemy laboratory (*v. Osten 1998*, 41–43).

Apart from clay plates and vessels used in the home, the Bilyar workshop yielded samples of technical ceramics: fragments of large thick-walled vessels (presumably, roasting vessels), tripods (*Fig. 14: 12–15*), lamps (*Fig. 14: 1–8*), crucibles (*Fig. 17: 2–9*), a muzzle (*Fig. 17: 1*), refractories (*Fig. 10: 4–5*), sphero-conical vessels (*Fig. 16*), small standard-sized saucers (38 specimens), which could have been used as Petri dishes (European alchemists used the term 'paropsis') (*Fig. 14: 9–11*) (*Albert the Great* /*Rabinovich 1983*, 390, comment 81/), obviously special-purpose vessels with perforated walls and bottoms (*Fig. 10: 1–3*), and clay balls 0.9–2.2 cm in diameter, which could have been used to mix the content and to even facilitate its boiling in hermetically sealed vessels-reactors (*Volkov 2004*, 146).

An oval clay container with dimensions of 18 × 10 × 4 cm, with 6 cells formed by one lengthwise and 4 lateral partitions (*Fig. 10: 8*), with traces of scum and

[14] In the words of Lucius Annaeus Seneca, "Gold is tested with fire, woman with gold, man with woman" (*Treasures of Antique Wisdom 2010*).

partly covered with a transparent glaze, was difficult to identify. Although it was found in one of the kilns from excavation XL, the given item was not likely part of a kiln, and we are still uncertain about its purpose.

Excavation XLI yielded one intact sphero-conical vessel and 83 fragments of other sphero-conical vessels. The existence of a certain interrelation between alembics and sphero-conical vessels was established a long time ago (*Dzhanpoladyan 1965*, 215; *Amindzhanova 1961*, 248). The upper horizon of the cultural layer at excavations XXVIII and XLI yielded almost equally high numbers of finds of both types of vessels. In this sense, one of the best examples is pit no. 27 (excavation XXVIII, 18 m to the south of the features of excavation XLI), which contained over 30 fragments of alembics and 43 fragments of clay sphero-conical vessels. It is rather unfortunate that their utility remained under-investigated.

Apart from highly volatile substances (mercury, etc.), in the process of distillation sphero-conical vessels could accommodate mother substances and final products (*Fig. 16*).

A clay 'cast' of a sphero-conical vessel ('turundzh') – a remainder of baked clay daub repeating the outer form of a vessel (*Fig. 17: 10*) – illustrates the preparation of cinnabar described in the 12th-century treatise *Description of Handicrafts* by Khubaysh Tiflisi. This is how Tiflisi describes the procedure: 'Take a glazed vessel of the turundzh form, i.e. with a narrowing base and narrow neck... fill it with mercury and add one-fourth [of the mercury's volume] of yellow sulphur, or, even better, one-sixth of it. Cover the neck with a copper plate, thoroughly daub the entire vessel with clay and place it in the sun for drying. Should the clay fracture, daub the vessel again to seal it well, fire sheep excrements in the kiln, leave the vessel inside the kiln and seal the kiln's outlet with clay. Keep the vessel inside for one day. After it is taken out, the cinnabar will be red and good!' (*Tiflisi /translation Mikhalevich 1976*, 68/).

Following *R. M. Dzhanpolyadyan* (*1982*, 23–25), *B. V. Lunin* (*1961*), *O. L. Vilchevsky* (*1961*), *T. D. Scanlon* (*1981*, 290) and other authors, I. V. Volkov insists that the main purpose of sphero-conical vessels was the storage and transportation of mercury (*Volkov 2004*, 146); therefore, the large-scale production of such vessels should have been organized in close proximity to areas rich in mercury deposits – Transcaucasia and Maverennakhr. Spherical-conical vessels produced within territories lacking deposits of mercury were basically used as chemical vessels (*Volkov 2004*, 139, 141). In the opinion of the majority of experts, sphero-conical vessels constitute an integral part of the nomenclature of Bulgar ceramics (*Mikhalchenko 1974*; *Halikov 1986*, 72–83; *Khlebnikova 1988*, 92–95). Glossy redware sphero-conical vessels from pre-Mongolian Bulgar sites are in no way different from Georgian specimens, with the exception of their dimensions, as the latter could be up to 30 cm in height and 20 cm in diameter.[15] Judging from the marks on the walls of one of such sphero-conical vessel, R. M. Ramishvili refers to it as a 'vessel for melting gold'. The find dates back to the 11th–12th centuries (*Ramishvili 2003*, Tab. 130: 16). It was probably intended for storage of so-called 'aurum potabile'. In Europe it could be a solution of gold trichloride or mercuric chloride in Tang Chinese alchemic texts (*Gě Hóng Pao-p'u-tzu 2001*, 445). Several fragments of a sphero-conical vessel of a similar size were found at the Bilyar workshop.

A generalising study comprising full morphological, technological and semantic analyses of these interesting vessels would shed light on many secrets of medieval handicrafts and alchemy, and outline vectors of cultural influences (*Nuretdinova 2011*, 51–62). The walls of the majority of sphero-conical vessels bear signs or symbols which may be not just tamgas, pointing to the producer or owner, but alchemic codes designating the contents or the contents' purpose. Other vessels from the excavation bear numerous different symbols scored on handles, walls and bottoms (*Fig. 14: 16–22*). Apparently, sphero-conical vessels are both of local and foreign origin. As for the origins of imported sphero-conical vessels, experts note the extensive distribution of the latter to Volga Bulgaria especially from Transcaucasia, particularly Dvin (*Mikhalchenko 1974*, 46–50; *Halikov 1986*, 72–83).

7. Glazed ceramics

An excavation yielded a comprehensive collection of glazed ceramics (127 specimens), with an almost equal proportion of items of local and foreign origin. Local glazed pottery was obviously produced in the workshop investigated at excavation XL, whereas imported items, similar to those obtained from excavation XL (*Valiulina 1991*, 78–96), originate from a wide spectrum of handicraft centres, with the predominant role of the Transcaucasian vector of cultural and economic contacts. Local glazed pottery is represented by small fragments, mainly fragments of lamps (21 specimens), imported items – by fragments (except for one case of a semi-destroyed vessel) of cup-shaped vessel-tripods and jars; in the majority of cases the glaze is variously tinted monochrome green, dim and blackened; fragments bear traces of soot, and the highest concentrations of finds were located next to production facilities. Two kilns, apart from fragments of alembics and sphero-conical vessels, yielded large fragments of thick-walled glazed vessels. Legs of one such vessel (tripod) were worn out or ground down to the required height (*Fig. 14: 14*).[16] While addressing the given group of glazed ceramics, one can hardly avoid recollecting strict requirements placed on laboratory dishes in alchemy literature.

Apart from traditional housekeeping equipment, residential premises discovered at excavation XL (unit no. 2) at the connecting point of excavations XXVIII, XL and XLI yielded a clay-ware set including two fragments of alembics, fragments of iron balls, metal slag, copper and lead ingots. Imported pottery is of better quality.

[15] National Museum of Georgia. Case no. 18. Clay vessels of the 11th–13th centuries (Dmanisi, Tbilisi, Zhinvali, Gudarekhi); no. C-504.

[16] Kazan University archaeological collection 285/199.

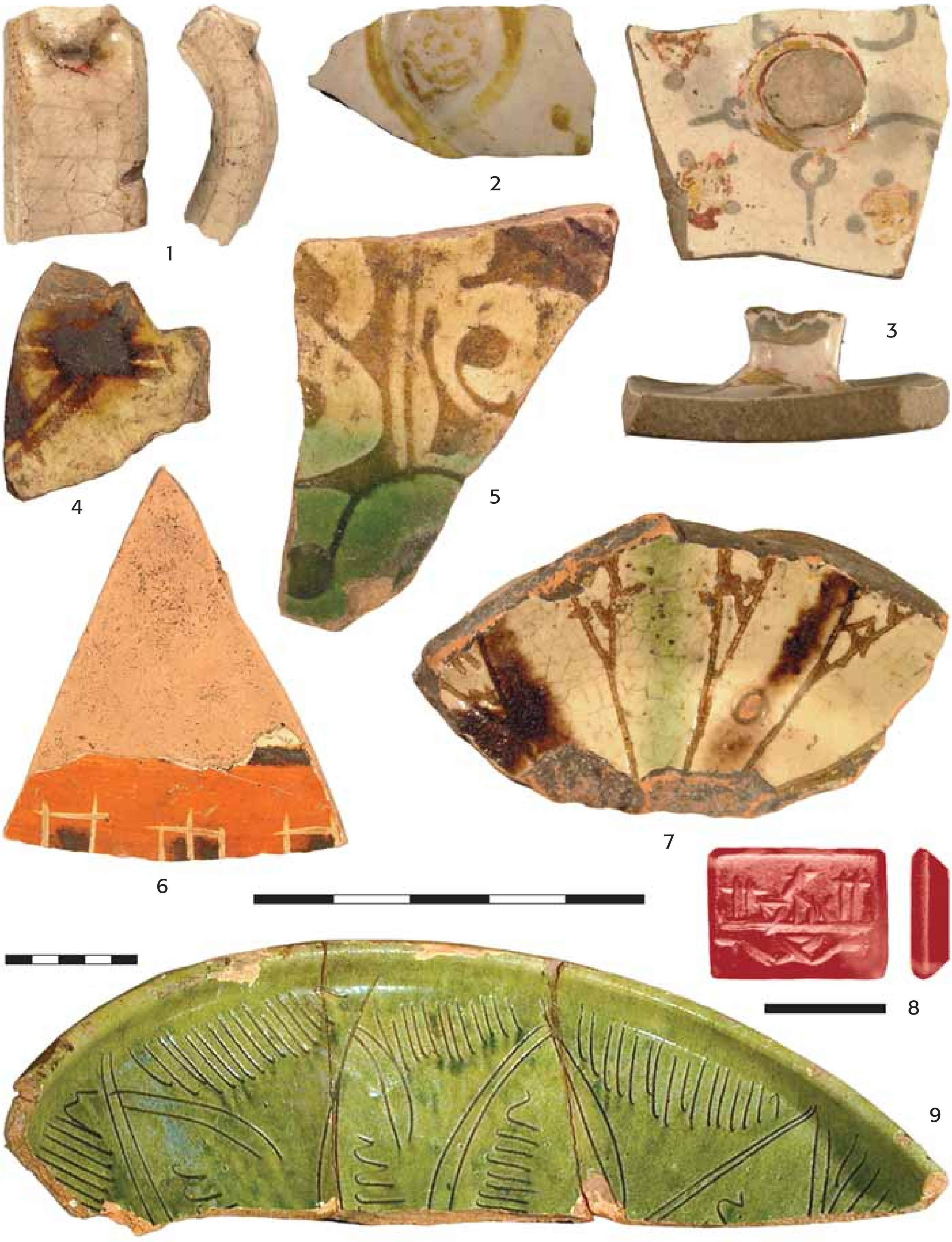


Fig. 20. *Imported items from the alchemy workshop (Bilyar excavation LXI). —* ***Obr. 20.*** *Importované předměty z alchymistické dílny (výzkum LXI v Biláru):* ***1, 2*** *– fragments of frit (stonepaste) vessels with lustrous paintings/fragmenty listrované keramiky „kašin“, Írán;* ***3*** *– ʻmina-iʼ keramika, Persie/Írán;* ***5, 7, 9*** *– glazed ceramics/glazovaná keramika;* ***8*** *– cornelian piece of a finger ring/karneolový buton prstenu. Photo/Foto by T. Valiulin.*

Fig. 21. *Stone necklace from Bilyar excavations LX and LXI:* ***1–6*** *– cornelian;* ***7*** *– crystal;* ***8, 11*** *– glass;* ***9, 10, 12*** *– amber (after S. I. Valiulina 2005, Fig. 46, I: 1–12). Photo by T. Valiulin. —* ***Obr. 21****. Korály z náhrdelníků z polodrahokamů, skla a jantaru z výzkumů LX a LXI v Biläru:* ***1–6*** *– karneol;* ***7*** *– křišťál;* ***8, 11*** *– sklo;* ***9, 10, 12*** *– jantar (podle S. I. Valiulina 2005, Fig. 46, I: 1–12). Foto T. Valiulin.*

A larger number of vessels feature polychromic glazing. Unit no. 2 yielded 9 fragments of frit (stonepaste) vessels with lustrous painting and a fragment of a 'mina-i' (an especially rare and precious type of Middle-East ceramics) vessel lid (*Fig. 20: 3*), whereas Bilyar sites yielded only 6 fragments of this sort (*Valiulina 2001*, 53–55). In terms of the quality and composition of the Kashan fabric, glazing and painting pattern, the vessel is associated with pottery produced in the Iranian city of Rey at the end of the 12th century – beginning of the 13th century. Other imported items include a semi-destroyed plate-type narrow-necked container, a glass finger-ring insert (*Fig. 21: 8*) and fragments of two glass tumblers of Russian origin (*Valiulina 2005*, Fig. 6: 1, 4). A fragment of a glass Byzantine bracelet (*Valiulina 2005*, Fig. 30: 4) was found outside the residential premises. A cornelian finger-ring insert (14 × 10 × 3 mm) with a carved two-line Arabian sign 'Happy with the authority of / God'[17] was found beyond the excavation area by members of the 1992 expedition (*Fig. 20: 8*).

8. Social status

The above list of expensive and prestigious items is indicative not only of the tastes of the workshop and residential premises owners, but, more importantly, of their capabilities. Albert the Great begins his treatise with an unambiguous warning: 'Our art is not for the poor, as each person attempting to spring into action should have enough money, at least for about two years…' In his eighth prescription he demands that 'nobody should undertake any required operations before he buys everything necessary for the given art. Should you get into the alchemic business without adequate funds, you will fail. You will lose everything you had before' (*Albert the Great /Rabinovich 1983*, 349–354/). Ar Razi's list of the necessary laboratory equipment also assumes a wealthy owner.

One can judge both the property and social status of the alchemist-glassmaker from the workshop's location in the handicraft centre of Bilyar, next to the most privileged producing units – blacksmithing and nonferrous metallurgy, glassmaking, jewellery and other artistic crafts, 200–300 m away from the complex of the all-brick buildings within the territory of excavation XXXVIII, the lord's residence, mosque and the mausoleum of nobles. The issues of social stratification in Bilyar still remain unexplored by scientists. However, the fact that the most important and 'expensive' producing units operated in the very centre of Bilyar (as in Suvar) supports the assumption that the Bulgar governors followed the lead of Timur and the governors of Bukhara and Ahsiket, who preferred the centre of the city to be settled with craftsmen who were to meet the needs of the courts and produce items for sale. The profit from sales of handicraft products added to the personal gains of the governors (*Papachristou — Ahrarov 1981*, 95).

According to S. v. Osten, alchemy laboratories in the Middle Ages were usually supported by monasteries and royal courts and were under the protection and patronage of the latter (*v. Osten 1998*). In Budapest, alembics were found on the grounds of Buda Castle in the layer corresponding to the 13th–14th centuries (*Gyürky 1982*, 154). The Bilyar workshop of an alchemist, jeweller and glassmaker was apparently part of the court economy and served to produce additional income.

9. Conclusion

The large concentration and archaeological context of special-purpose alchemic vessels – alembics (*Fig. 2: 2–5*), decanters (*Fig. 7: 1*), test tubes, flasks (*Fig. 8: 2; 6: 11*) as well as other vessels made it possible to locate

[17] I appreciate the assistance of Prof. Muhammad Batajni (Yarmouk University, Jordan) in gaining an understanding of the meaning of the sign.

*Fig. 22. Raw amber. Bilyar. Excavation XLI, pit 18: **1** – clay bowl АКУ285/5171; **2** – amber АКУ285/5172. Photo by T. Valiulin. — **Obr. 22.** Surový jantar. BILÄR. Výzkum XLI, jáma (jímka) 18: **1** – hliněná mísa; **2** – jantar. Foto T. Valiulin.*

*Fig. 23. Experimental modelling of the process of distillation with the use of a type 2 alembic (replica) and a sphero-conical vessel. Photo by A. Frolov. — **Obr. 23**. Experimentální simulace destilace za použití alembiku typu 2 (replika) a nádoby srdcovitého tvaru. Foto A. Frolov.*

the workshop of an alchemist, jeweller and glassmaker from the end of the 12th century to the beginning of the 13th century in the centre of Bilyar (*Valiulina 2005*, 146–165). It is important to note that it was a workshop, not a laboratory, because the complex had a pronounced industrial character. The close connection with the production of alchemy is a distinctive feature of Eastern alchemy as a whole.

Alembics are quite common for Islamic glassmaking, especially since the 9th–11th centuries, and always date within the pre-Mongolian period (*Savage-Smith 1997*, 42; *Carboni 2001*, 144–145, cat. 34b, c; *Kröger 1995*, 187–188, no. 239–242; *Bass — Lledo — Matthews 2009*, pl. 31, 32).

The highest concentration of finds of sphero-conical vessels and alembics at handicraft centres in Volga Bulgar cities, especially in Bilyar, is indicative of the priority of the technical function of the glassware.

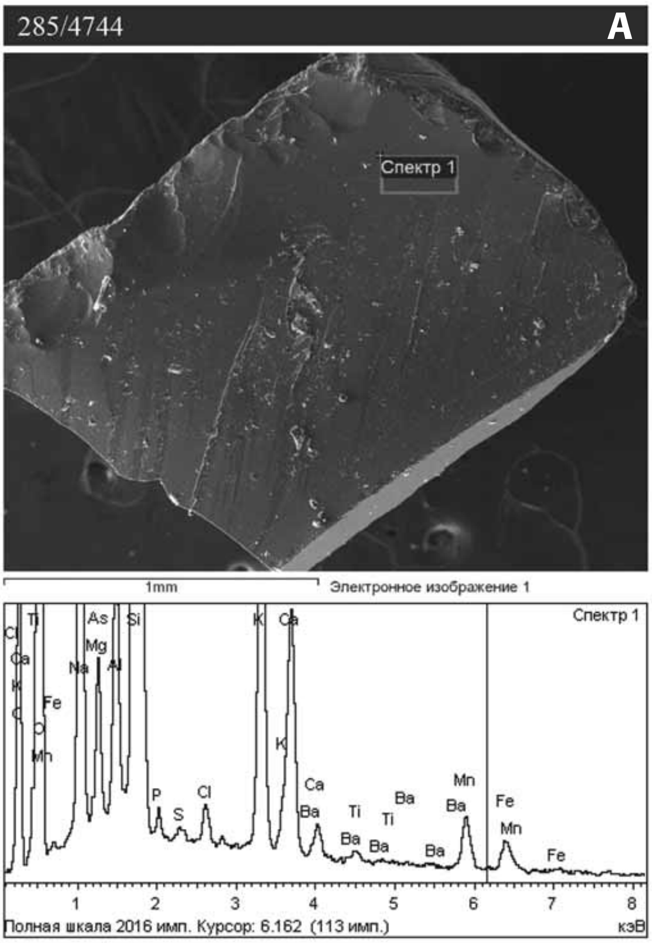
Apparently for the first time ever, the Bilyar workshop yielded a whole set of sphero-conical vessels and alembics found in small kilns. The completeness of the set is confirmed by the correspondence of the diameter of the alembic's collar and the head of the sphero-conical vessel, as well as by the diameter of the sphero-conical vessel's outlet and diameter of the alembic's outflow tube. Alembics of Bilyar origin are distinguished by standardized forms and sizes and the stable formulation of glass preconditioned by the specificity of the raw materials resources of the Volga-Kama region. This is indicative of the mass, purpose-focused and standardized production of special glassware in Bilyar at the end of the 12th century and beginning of the 13th century. The experiment (*Fig. 23*) conducted in the course of the study proved the hypothesis of the main function of the given vessels: along with sphero-conical vessels, alembics were used for distillation and, possibly, the rectification of mixtures.

The considered objects and materials are representative of a working place or 'production facilities' of an alchemist-craftsman who combined chemical experiments with jewellery production and who was capable of providing for himself with the necessary special-purpose glassware. The scope of alchemy activity was determined based on the analysis of alembics, as all other obtained materials are related to handicraft jewellery, which is quite common for Oriental alchemy as a whole. According to ar Razi, almost all equipment in use in the alchemic laboratory can be found at a goldsmith's workshop. Being experiment-based, Oriental alchemy applied a different methodology and tools when working with chemicals (*Watt 1976*, 61), unlike the mystic and allegorical alchemy of western Europe (*Canseliet 2002*).

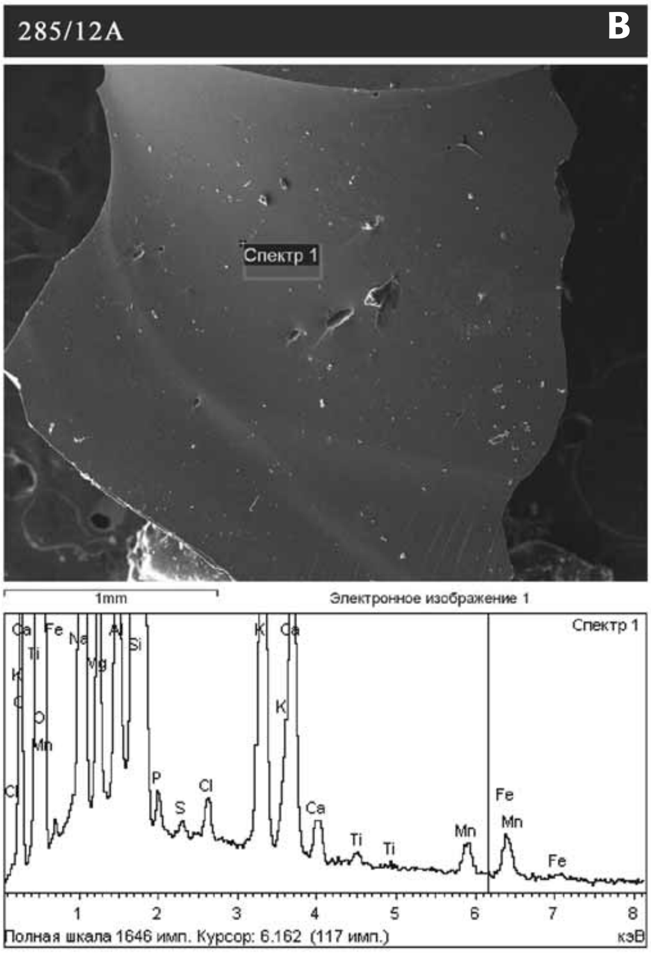
As for the workshop profile, toolkits and materials, the Bilyar complex is associated with the Armenian centre of alchemy. Judging from numerous alchemy texts, the latter was focused on regular handicraft tasks related to the production of pure substances and their subsequent use for making drugs, paints, chemicals and alloys — 'true gold' and gold-coloured metals. The best part of alchemy literature is dedicated to operations aimed at the purification of reagents, including distillation procedures (*Kazandzhyan 1955*, 99).

The most telling feature associated with alchemy practices among Bilyar analogies to Transcaucasian materials is the above-mentioned pit no. 27 at excavation XXVIII, which yielded numerous sphero-conical vessels and alembics, as well as other items made of glass, often unique and directly analogous to Transcaucasian samples – fragments of window glass of a relief-cell design, thick-walled shape-blown bottles, a tumbler with a polished ornament, a 1a type lamp and a 2a type bottle (*Valiulina 2005*, 35, 50).

Most likely, alchemy in crafts-oriented Volga Bulgaria evolved on the basis of local hi-tech production, under the influence of Oriental, in particular, Armenian, alchemy. Thanks to the wide trade and handicraft connections of merchants and migrants, Armenians played a great role in the dissemination of alchemy knowledge to other countries (*Arakelyan 2003*, 348).



Элемент	Весовой %	Атомный%	Соед.%	Формула
Na K	8.43	7.76	11.37	Na2O
Mg K	1.29	1.12	2.13	MgO
Al K	1.90	1.49	3.58	Al2O3
Si K	32.03	24.12	68.52	SiO2
P K	0.28	0.19	0.65	P2O5
S K	0.13	0.09	0.33	SO3
Cl K	0.44	0.26	0.00	
K K	4.48	2.42	5.40	K2O
Ca K	2.94	1.55	4.12	CaO
Ti K	0.13	0.06	0.21	TiO2
Mn K	1.39	0.54	1.80	MnO
Fe K	0.87	0.33	1.12	FeO
As L	0.14	0.04	0.18	As2O3
Ba L	0.14	0.02	0.16	BaO
O	45.41	60.02		
Итоги	100.00			



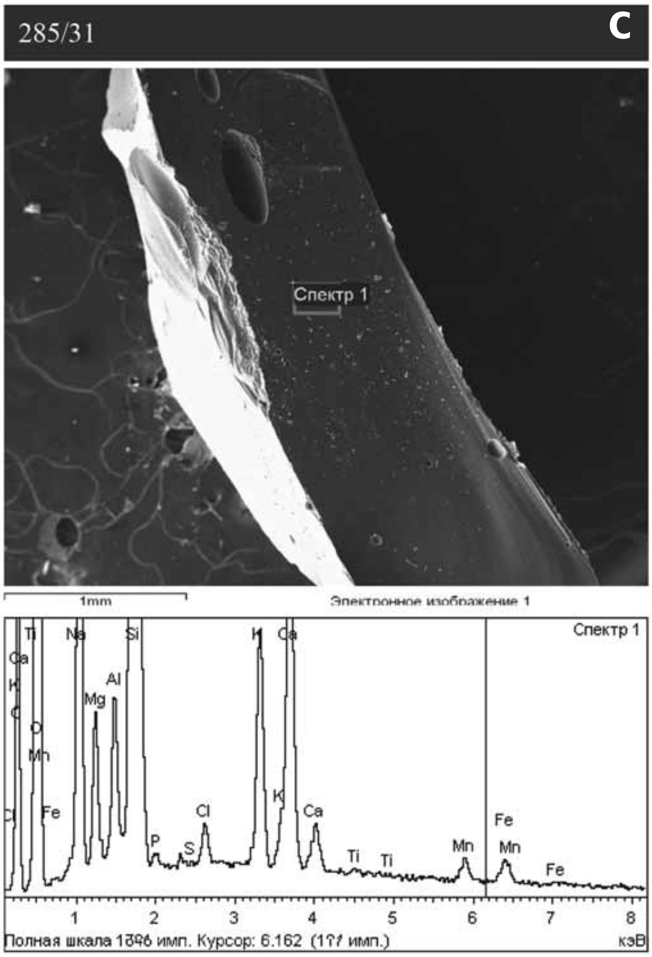
Элемент	Весовой %	Атомный%	Соед.%	Формула
Na K	10.37	9.48	13.97	Na2O
Mg K	1.56	1.35	2.58	MgO
Al K	2.01	1.57	3.80	Al2O3
Si K	31.11	23.28	66.55	SiO2
P K	0.33	0.22	0.75	P2O5
S K	0.11	0.07	0.28	SO3
Cl K	0.32	0.19	0.00	
K K	4.46	2.40	5.37	K2O
Ca K	3.01	1.58	4.20	CaO
Ti K	0.14	0.06	0.23	TiO2
Mn K	0.57	0.22	0.74	MnO
Fe K	0.94	0.35	1.21	FeO
O	45.09	59.24		
Итоги	100.00			

Fig. 24A, B. *Spectral electron microscopy (SEM) analysis of glass alembics. —* ***Obr. 24A, B.*** *Výsledky analýzy skleněných alembiků provedené rastrovacím elektronovým mikroskopem (SEM).*

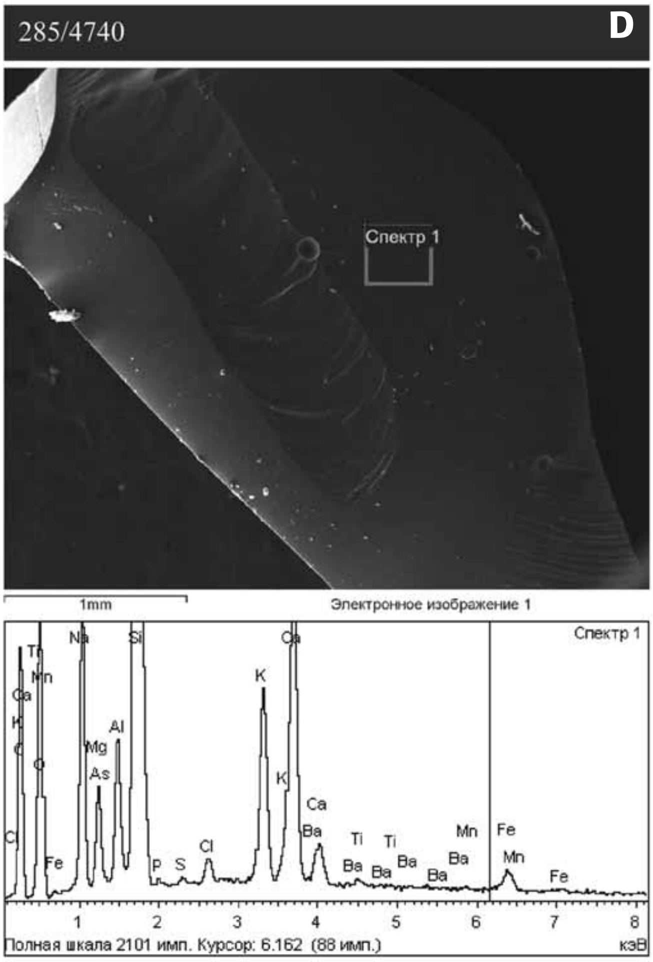
Judging from the results of the stratigraphic analysis and the nature of obtained materials, the Bilyar workshop of the alchemist, jeweller and glassmaker functioned at the very end of the 12th century and beginning of the 13th century in the centre of Bilyar. The majority of finds were in use for a long period of time. Archaeometric dating was performed on the following items: Iranian fragments of frit (stonepaste) vessels of a lustrous design and 'mina-i', Russian glass tumblers, a lamp and a bead necklace of semi-transparent yellow glass.

Built structures at excavation XLI are covered with a thick layer of ash and coal, which is typical for the upper horizon of the cultural layer throughout the entire territory of the settlement. Conflagration completes the image of terrible devastation and carnage in the city during its capture by the Mongol-Tatars in 1236. The top surface of the cultural layer contains a large number of human bones. In the corner of one of the maintenance buildings in the northwest segment of the excavation a burnt skeleton of a man[18] was found, with a metal arrowhead beneath it.

[18] Anthropological analysis was accomplished by I. R. Gazimzyanov.



Элемент	Весовой %	Атомный%	Соед.%	Формула
Na K	8.36	7.68	11.27	Na2O
Mg K	1.61	1.40	2.67	MgO
Al K	1.25	0.98	2.37	Al2O3
Si K	32.05	24.12	68.57	SiO2
P K	0.19	0.13	0.43	P2O5
S K	0.09	0.06	0.22	SO3
Cl K	0.54	0.32	0.00	
K K	3.39	1.83	4.08	K2O
Ca K	5.48	2.89	7.66	CaO
Ti K	0.12	0.05	0.20	TiO2
Mn K	0.65	0.25	0.84	MnO
Fe K	0.89	0.34	1.15	FeO
O	45.38	59.94		
Итоги	100.00			



Элемент	Весовой %	Атомный%	Соед.%	Формула
Na K	6.94	6.51	9.36	Na2O
Mg K	1.74	1.55	2.89	MgO
Al K	2.08	1.66	3.93	Al2O3
Si K	29.19	22.41	62.44	SiO2
P K	0.20	0.14	0.45	P2O5
S K	0.14	0.09	0.34	SO3
Cl K	0.62	0.37	0.00	
K K	4.76	2.62	5.73	K2O
Ca K	8.51	4.58	11.90	CaO
Ti K	0.19	0.08	0.31	TiO2
Mn K	0.14	0.06	0.18	MnO
Fe K	1.31	0.51	1.68	FeO
As L	0.04	0.01	0.06	As2O3
Ba L	0.08	0.01	0.09	BaO
O	44.06	59.39		
Итоги	100.00			

Fig. 24C, D. *Spectral electron microscopy (SEM) analysis of glass alembics. —* ***Obr. 24C, D.*** *Výsledky analýzy skleněných alembiků provedené rastrovacím elektronovým mikroskopem (SEM).*

Finds of chemical glassware in Bilyar and other pre-Mongolian cities of Bulgaria, and the discovery of the workshop of an alchemist, jeweller and glassmaker in the centre of Bilyar led the conclusion about the existence of alchemy in Volga Bulgaria in the 12th century and beginning of the 13th century. Thus, archaeologists had a rare opportunity to learn about the peculiarities of the initial development stage of the science of alchemy – experimental, handicraft or practical chemistry in eastern Europe.

English by the author,
proofreading by Zuzana Maritzová

Souhrn

1.–2. Úvod, topografie dílny a objektů

V 10. století vznikl na území středního Povolží a Pokamí stát Volžské Bulharsko, který dosáhl největšího rozkvětu v době 12. až počátku 13. století. Dokládá to mimo jiné rozsah mezinárodního obchodu i vysoká úroveň řemesel, mezi která patřilo i technologicky vyspělé sklářství a výroba glazované keramiky.

V centru města Bilär, které bylo hlavním městem Volžského Bulharska v předmongolském období, odkryl výzkum Kazaňské univerzity, vedený autorkou příspěvku, alchymistickou dílnu, ve které byly vyráběny nádoby ze skla, určené pro alchymistickou činnost a pracovalo se s barevnými a drahými kovy (například se zlatem ryzosti 850). Předpokládané technologické postupy byly ověřovány pomocí metod SEM a XRD.

Předmongolský horizont osídlení reprezentovala kulturní vrstva o mocnosti 45 až 50 cm. Velká část této vrstvy, i vrstvy v sektoru XL, byla narušena dlouhodobou hlubokou orbou a mladšími zásahy. Přímo pod ornicí však byly identifikovány středověké objekty, z nichž většina měla výrobní charakter. Nejvýznamnější byly nálezy menších pícek ve střední části výzkumu (*obr. 1b*: *2* a *3*) a u západního profilu výzkumu (*obr. 1b*: *K1*). Pícky byly pravidelně situovány v jamách, jejichž povrch se rýsoval pod ornicí, tedy v hloubce 45 až 50 cm.

Konstrukce pícek i materiál, použitý na jejich stavbu ukazovaly, že nejde o kuchyňská zařízení. Zřetelně se odlišovaly od jiných technologických tepelných zařízení, známých z Biläru, jako byly hrnčířské pece (*Kokorina 1983*, 50–67), metalurgické (*Halikov 1976*, 64–74) nebo sklářské pece (*Valiulina 2003*, 444–450).

Zařízení, používaná alchymisty, byla nazývaná „pece filozofů" a situovaná v menších zahloubených objektech. Albert Veliký popisuje konstrukci takové pece: „vykopej v zemi jámu, hlubokou jeden loket a širokou kolem dvou nebo o něco větší a vymaž ji hrnčířskou hlínou. Nad (jámou) postav kruhovou stavbu, rovněž omazanou hrnčířskou hlínou… Mezitím vyrob z hrnčířské dílny kruhový základ (disk), který vydrží silný žár… Pomni, že nad základem je nutné umístit keramický rošt (také se používaly keramické trojnožky), na kterém budou stát nádoby, obsahující všechny substance, potřebné pro tavbu různých materiálů a pod roštem topivo (*Albert the Great*/*Albert Veliký* /překlad: *Rabinovich 1983*, 354/). Funkci roštu/trojnožek mohly zastávat také široce rozevřené nádoby na třech nožkách (*obr. 14: 12–15*), které byly při výzkumu také nalezeny.

Dále bylo uvedeno, že všechny alchymistické činnosti „je nutné provádět v chladném a vlažném prostředí" (*Albert the Great*/*Albert Veliký* /překlad: *Rabinovich 1983*, 361/). Umístění v zahloubeném prostoru splňovalo tento požadavek a v dílně bylo nejen chladné a vlažné prostředí, ovšem také tmavé, což dokládají četné nálezy keramických lampiček (58 exemplářů celých i zlomků, *obr. 14: 1–8*) i zlomek skleněné lampy. Lampičky jak olejové, tak na naftu, mohly ovšem mít také funkci nahřívací (*Karimov 1957*, 62–63, 107, 124; *Poisson 2002*, 204).

3. Sklo

3.1. Alembiky

Z výzkumu pochází více než tři sta zlomků různých skleněných výrobků včetně laboratorních nádob – alembiků. V dílně bylo 35 alembiků, dalších 29 exemplářů bylo součástí depotu (*obr. 15: 2*), nalezeného v jihovýchodní části zkoumané plochy v krátkodobě používané hospodářské jámě 9a. Nádoby byly uložené v rohu jámy, původně snad v bedně z březové kůry. Tento soubor nabízí maximum informací o alembicích: jeden exemplář se podařilo sestavit kompletní a ostatní je možné prezentovat v kresebné rekonstrukci. Depot obsahoval i další zajímavé předměty jako tři prubířské kameny, 27 astrogálů z kůstek berana, většinou provrtaných nebo s jiným opracováním; nahoře byla uložena železná sekera, bronzový klíč (*obr. 15: 1)* a antropomorfní plastika – amulet ze zelené břidlice, představující pohanského boha Tengri Turci (*obr. 15: 5*).

Celkem bylo v Biläru nalezeno kolem 150 alembiků (ve zlomcích i kompletní exempláře). Většinou byly vyfouknuty ze světle zelenomodrého skla různé intenzity a odstínů, pouze šest zlomků bylo ze skla olivově zeleného a čtyři ze skla bezbarvého. Sklo bylo čisté, nebo lehce matné, s množstvím svisle podlouhlých bublinek, prakticky bez patiny nebo korozních produktů na povrchu. Dokládá to vysokou chemickou odolnost skla, ze kterého byly nádoby vyrobené. Všechny jsou nezdobené.

Dva typy alembiků:

Typ 1 – arménská alchymistická pojednání označují alembik s klenutou helmou jako „dýni" (*Dzhanpolyadyan 1974*, 40). V Biläru je tento typ zastoupen jedním zlomkem (*obr. 2*). Má hřibovitý tvar a sestává z vysokého válcovitého límce a oblé helmy velkého průměru. V místě přehybu helmy nad límcem je napojena trubice, směřující dolů. V kupoli se během destilace kapky srážely a trubicí stékaly do záchytné nádoby. Vyobrazení procesu se dochovalo na kresbě destilačního přístroje od Leonarda da Vinciho (*Huwer 1992*, 136, obr. 194).

Podle stejného principu byly konstruovány destilační přístroje na výrobu růžové vody, hojně používané v lékařství i kosmetice (*Dzhanpolyadyan 1965*, č. 2, 213).

Typ 2 – malé alembiky (*obr. 3–5*), válcovitého nebo kuželovitého tvaru o výšce 7–10 cm s průměrem okraje 3,5–6 cm (většinou 4–4,5 cm). Tento typ nemá válcovitý límec, okraj helmy je přehnutý dovnitř, rovný nebo zaoblený. Ve spodní části hlavy je umístěná trubice o délce 8–11 cm, zahnutá dolů, nebo téměř rovná. Bilärské alembiky tohoto typu mají většinou zahnutou trubici, což může znamenat jejich použití k více účelům.

Alembiky tohoto typu mohly být součástí destilačních aparatur jako v případě 1. typu, nebo sloužit k nalévání tekutin do nádob s úzkým hrdlem, jako byly například sférokonické nádoby (nádoby srdčitého tvaru). Existuje také názor o možném používání v lékařské praxi (*Mukhametzhanov et al. 1988*, 178). Na jedné miniatuře z Bagdádu je alembik používán k odsávání krve (*Dzhanpolyadyan 1974*, 40). V arabských východních zemích byly však v raném středověku používány k tomuto účelu častěji bronzové kanyly (*Metz 1973*, 216).

J. Kröger na základě nálezů nádob srdčitého tvaru a alembiků v měšťanských domech v Nišapuru v 9.–10. století přepokládal jejich použití při domácí výrobě růžové vody, palmového vína, nebo sorbetu, ovšem hlavní použití bylo ve farmacii a alchymii (*Kröger 1995*, 186–188). Široké použité alembiků předpokládají i další autoři (*Thomas 2009*).

Jistá skepse panuje v otázce použití alembiků 2. typu v procesu destilace. Abychom prověřili hypotézu o použití nádob srdčitého tvaru (sférokonických nádob) a alembiků typu 2, připravili jsme na semináři „Technologie středověkých řemesel" na Kazaňské univerzitě experiment: keramická sférokonická nádoba na stojanu byla překryta alembikem a jeho trubice ústila do záchytné nádoby (byla použita skleněná baňka s možností sledovat destilační proces). Ohřev dodala lihová lampa. Sférokonickiá nádoba byla nakloněná tak, aby trubice alembiku směřovala přímo do záchytné nádoby. Jako destilovaná kapalina byla použita voda (*obr. 23*). Pokus potvrdil, že lze takovou sestavu pro destilaci používat (*Nuretdinova — Valiulina 2015*, 153–155). Pro zajištění hermetického utěsnění nádob bylo nutné spoje vymazat speciální hlínou nebo hmotou z vaječného bílku (*Thomas 2009*, 36).

Pomocí těchto alembiků bylo možné zajistit i složitější úkony – při změně naklonění celé aparatury (k čemuž byl nejvhodnější srdčitý tvar nádob), mohlo být dosaženo vyšší čistoty nebo oddělení směsí. Instalace sférokonických nádob s destilovanou směsí ve svislé poloze a s použitím alembiku typu 2 byla vhodná pro redestilaci a rektifikaci, což znamená oddělování dvou- nebo vícesložkových směsí pomocí různých bodů varu (lat. *rectus* = rovný a *facere* = zhotovit).

Bilärské alembiky obou typů odpovídají nádobám z 9.–11. století z arménského města Dvin. Alembiky ze Střední Asie mají jiné rozměry a proporce (průměr 4,0–4,5 cm a výšku 4,5–5,1 cm). Bilärské alembiky pocházejí z vrchního horizontu kulturní vrstvy s datováním do 12. – počátku 13. století.

3.2. Zkumavky

Zkumavka je v Biläru doložena jedním zlomkem[19] (*obr. 8: 2*). Spodní baňatá část přechází plynule v úzké tělo (průměr 3 cm, výška nejméně 7 cm). Sklo silné 1,5 mm je světle zelené, čiré. Nález pochází ze sektoru XXVIII, z těsné blízkosti dílny alchymisty (sektor XLI) z vrstvy z počátku 13. století. Skleněné zkumavky jsou známé ze Střední Asie (*Abdurazakov — Bezborodov — Zadneprovsky 1963*, 134). Tyto účely mohly také plnit kónické nádobky z Bolgaru/Bulharu (*Polyboyarinova 1988*, 204, obr. 88: 6).

3.3. Sférokónické nádoby (nádoby srdčitého tvaru)

Nádoba z Biläru (*obr. 8: 3*) byla vyrobena z tmavého skla o síle 0,8 cm, otvor v hrdle má průměr 0,4 cm. Vnější povrch nese péřový dekor provedený bílým emailem. Vzor vychází z římských tradic a v 11.–13. století byl oblíbený v oblasti Egypta a Sýrie.

[19] БМ, BXXVIII/6858.

3.4. Baňky

Na středověkém Východě byly rozšířené nádoby s vysokým štíhlým hrdlem a klenutým tělem (*Abdurazakov — Bezborodov — Zadneprovsky 1963*, 133; *Kudryavtsev 1993*, 233, obr. 64: 23; *Shishkina 1986*, obr. 11: 3, 8). Z Volžského Bulharska, z města Suvar,[20] pochází nález válcovitého hrdla s mírným zúžením ve středu, o průměru 1,5 cm a délce 9,2 cm. Sklo je čiré, bezbarvé se žlutozeleným nádechem (*obr. 6: 11*; *Smirnov 1941*, 166). Analogické nálezy ze Střední Asie jsou známé z Nisy, Mervu, z Domu Chánů (Turkmenistán) s datováním do 12. století (*Charyeva 1979*, 92, obr. 2: 8). Další nálezy pocházejí ze Zakavkazí – z Dvinu (Arménie), Kabaly, Šemachu (Ázerbajdžán) z 9. – počátku 13. století (*Dzhiddi 1981*, 67).

3.5. Láhve na dekantaci (láhve s vnitřním prstencem)

Láhve zvláštní konstrukce, které mají ve středu těla vnitřní prstence, sloužily na odlučování nečistot od tekutin. Byly známé v Sýrii ve 4.–5. století n. l. (*Stern 1977*, pl. 9, 27: A, B; *2001*, 252, č. kat. 138). Zlomek takové nádoby z čirého bezbarvého skla se žlutozeleným nádechem (průměr 14 cm) pochází ze Suvaru[21] (*obr. 7: 1*). Další láhve se vyskytují v 10. století v Nišapuru (*Kröger 1995*, 109, č. 154, 155), Dvinu (*Dzhanpolyadyan 1974*, 140), Novogrudku (*Gurevich 1981*, 65) a v Misriane ve 12. století (*Mirzaakhmedov 2011*, 107, fig. 8). Láhve s vnitřním prstencem sloužily lékárenským i alchymistickým potřebám již v antice i v Byzantské říši.

Láhve z Novogrudku a Dvinu mají také vývalky na spodní části hrdla jako další zábranu pro zachycení kalů a nečistoty (*obr. 7: 2, 3*) a jsou datovány do 11.–12. století (*Dzhanpolyadyan 1965*, 216). Podobné nádoby jsou známé také ze Střední Asie (*Shishkina 1986*, fig. 6: 19).

Láhve, rozšířené ve 13. a 14. století na území Německa, Čech, Maďarska i Balkánu, označované jako dvojkónické, měly rovněž vnitřní prstenec (*obr. 7: 4–7*). Byly používané v laboratořích, lékárnách i vinařství (*Prohaska-Gross 1992*, 93–94, Abb. 115, 116; *Han 1975*, 122–123, fig. 9, 10; *Holl-Gyürky 1986*, 72, fig. 3,3 a fig. 6,2; *Bikic* 2006, 203–204, Fig. 4: 2, a 5: 10; *Beutmann 2014*, 156, Abb. 4: 6; *Sedláčková et al. 2014*, 224–225, 231, fig. 6: 1, 3–6; 9; 10; 11: 11*)*.[22]

Složení skla z Biläru bylo zjišťováno pomocí různých analytických metod, z nichž nejspolehlivější výsledky přinesla rastrovací elektronová mikroskopie (SEM mikrosonda s EDS analýzou) (*Tab. 1* a *2*; *obr. 24*). Chemické složení alchymistického skla z Biläru, které představuje 73 % všech nálezů skla ve městě (*Valiulina 2005*, 76), dokládá sodno-popelový typ Na-K-Ca-Mg-Al-Si (+Mn +Fe). Sklo tohoto složení mělo ve středověku široké uplatnění především při výrobě tzv. islámského skla, a to s různými variantami, které vyplývají z použití vstupních surovin z různých regionů.

Studium specifiky surovinových zdrojů Středního Povolží a Předuralí vysvětluje zvláštnosti složení skla z Biläru (*Valiulina 2014b*, 280–284) lokální výroby typu Na-K-Ca-Mg-Al-Si (+Mn +Fe).

Vedle hotových výrobků ze skla byly při výzkumu nalezeny doklady výrobního charakteru jako slitky a vlákna ze skla, polotovary či zlomek masivní pánvičky se zbytkem skla (*obr. 9*). Potřebu skleněných nádob patrně řešili alchymisté výrobou na místě z polotovarů. Potvrzují to i středověké arménské alchymistické spisy.

4.–7. Hmotné doklady šperkařství a alchymie, prubířské kameny, technická a glazovaná keramika

Sklo v dílně alchymisty, klenotníka i skláře mohlo mít použití i jiným způsobem. M. Chapman, který se zabýval způsoby zesílení barvy zlacených bronzových předmětů v 18. století, nalezl ve starších pramenech receptury, podle kterých se k tomuto účelu používal čpavek, dusičnany, měděnka a další materiály včetně skla (*Chapman 1995*, 235). Ve slitinách barevných kovů se totiž nacházejí příměsi jako cín a zinek, k jejichž odstranění podle Theophila napomáhá drcené sklo (*Eniosova — Reren 2011*, 248). Kulturní vrstvy i výplně všech objektů obsahovaly popel, uhlíky a odpad řemeslné výroby. Byly v nich také zlomky síry a na některých skleněných nádobách byly i stopy rtuti (*Valiulina 1998*, 90).

Vedle kusů železné strusky (*obr. 13*) byly nalezeny zlomky železných předmětů jako zámky, klíče, hřebíky a také olověné plomby, kovová závaží ve tvaru kubusu (*obr. 19: 6, 7*) a kamenná závaží (*obr. 19: 15*), jaká jsou známá z předmongolského Bajkananu (*Akhmedov 2003*, tab. 193: 31), i kamenné brousky (*obr. 12*).

Další četné nálezy dokládají šperkařskou výrobu: formy na odlévání (*obr. 17: 11–13*), třecí kameny (těrky) a podložky, masivní desky (podložky?) s obroušeným povrchem a jindy vyhlazeným do vysokého lesku, prubířské kameny (*obr. 19: 8–14*), technická keramika (*obr. 17: 1–10*), kuchyňská a glazovaná keramika (*obr. 20: 1–7, 10*), měděné slitky a plechy, ingoty (*obr. 18: 13, 15*), olovnatocínové slitky, odstřiky cínu, bronzový mincovní ingot soum (*obr. 19: 16*), fragment zlaté folie, stříbrná náušnice (*obr. 18: 5*), železná pinzeta (*obr. 12: 4*), zlomky mědi, měděných a bronzových předmětů včetně splétaného náramku (*obr. 18: 6*), prsten (*obr. 18: 1*), nášivky (*obr. 18: 3, 11–12*), kování okraje dřevěné nádoby (uvnitř se dochovalo zuhelnatělé dřevo), několik zlomků kovové nádoby, jehla (*obr. 18: 7, 9*), dva knoflíky – zvonky (*obr. 18: 4*) a další předměty (*obr. 18: 10, 14*). Zlomek bronzového předmětu z tenkého bronzového plechu nese výzdobu v podobě ryb, zhotovenou technikou tepání do formy (*obr. 18: 2*). Chemické složení několika kovových předmětů bylo zjištěno metodou XRF (rentgen fluorescenční analýzou).

8. Sociální status

Vysokému ekonomickému a sociálnímu postavení alchymisty – skláře a klenotníka – nasvědčuje umístění dílny v řemeslnickém centru Biläru, v oblasti privilegovaných zpracovatelských provozů železa a barevných kovů, sklářství, šperkařství a řady dalších uměleckých řemesel. Nacházela se zhruba dvě stě až tři sta metrů od palácového komplexu, zjištěného výzkumem v sektoru XXXVIII. Komplex zahrnoval dům feudála, mešitu a mauzoleum pro elity. Situování vysoce ceněných a luxusních výrob přímo v centru Biläru (stejně jako v Suvaru) dovoluje předpoklad, že bulharští panovníci způsobem života následovali Timura, vládce Buchary a Aksiketu a sídlili v prostředí řemeslníků, vyrábějících pro potřeby dvora i na prodej. Zisky z výrobků byly jedním ze zdrojů příjmů vládců.

Ve středověku laboratoře existovaly často v klášterech (*v. Osten 1998*), na dvorech panovníků a pod jejich patronací. Nález alembiku z Budapešti pochází z paláce z vrstev 13.–15. století (*Gyürky 1982*, 154).[23] Pravděpodobně také v Biläru fungovala dílna v systému palácového hospodářství, jako jeden ze zdrojů příjmů.

9. Závěr

Posuzované objekty a nálezy reprezentují výrobní místo a zároveň výrobní možnosti alchymisty-řemeslníka, který spojil chemické experimenty se šperkařskou výrobou a byl schopný se sám zásobovat nádobami ze skla.

Hlavním dokladem profilace dílny jsou chemické nádoby – alembiky, ačkoliv ostatní nálezy se vztahují především k práci šperkaře. Toto spojení je běžné v celé orientální alchymii. Ar-Razi uvádí, že téměř všechny laboratorní aparatury lze nalézt rovněž u zlatníků. Východní alchymie, založená na experimentech, používala různou metodiku a laboratorní nástroje (*Watt 1976*, 61) na rozdíl od západoevropské alchymie, založené na mystice a alegoriích (*Canseliet 2002*).

[20] ГИМ, №77908, оп.2189, №31485.

[21] ГИМ, №77908, оп.2189, №1495.

[22] Pozn. H. Sedláčková: Z našich zemí, tj. z Čech, Moravy ani z Bratislavy nemáme přímé doklady o používání lahví s vnitřním prstencem v lékárenství nebo alchymii, ovšem první pravděpodobné laboratoře jsou známé až ze 2. poloviny 15. – 1. poloviny 16. století, kdy láhve tohoto typu již nebyly známé (*Sedláčková 2007*, 217 a 218). Velmi pravděpodobné je však jejich používání při dekantaci vína. Nápadný je rovněž výskyt těchto lahví ve 2. polovině 13. až počátku 14. století v Brně, v objektech s nálezy tyglíků, patrně souvisejících se zjišťováním kvality barevných kovů nebo stříbra (např. Kozí, parc. 54, jímka 10, nám. Svobody 17, jímka 547, Rašínova/náměstí Svobody, vrstva K 5157 ad.). Četné jsou tyto láhve i na hornickém sídlišti v Jihlavě - Starých Horách, kde byly těženy stříbronosné rudy (*Hrubý et al. 2006*).

[23] Pozn. H. Sedláčková: O něco starší alembik pochází z jímky v Bratislavě, sloužící patrně u kláštera klarisek (*Sedláčková et al. 2014*, 222 a 223, fig. 4: 15).

Charakter bilárského komplexu má blízké analogie k arménskému středisku alchymie, které podle četných textů řešilo úlohy sloužící rozvoji řemesel: získání čistých substancí, odloučení nečistot, výrobu barev, chemikálií, „pravého zlata" a zlatě zabarvených kovů. Velká část alchymistické literatury je věnována čištění reagentů pomocí destilace.

Lze předpokládat, že alchymie ve Volžském Bulharsku vznikla pod vlivem východní, zejména arménské alchymie, což bylo podmíněno rozvinutými obchodními i řemeslnickými kontakty obou zemí (*Arakelyan 2003*, 348).

Dílna alchymisty a šperkaře, která vznikla v centru Biláru na konci 12. – počátku 13. století pomáhá k dataci celého komplexu. Většina nálezů má totiž dlouhodobější charakter a jen některé jsou určeny přesněji: íránská keramika typu „kašina" s listrem,[24] ruské skleněné číšky, lampa a korály z poločirého žlutého skla.

Objekty v sektoru XLI byly převrstveny mocnou spálenou vrstvou, což je typické pro celý prostor města. Požáry provázely okupaci mongolsko-tatarskými dobyvateli v roce 1236 a horní vrstvy obsahují také množství jednotlivých lidských kostí zejména v severozápadní části výzkumu. V rohu jedné z hospodářských staveb byla odkryta mužská kostra se železným hrotem šípu.

Nálezy laboratorních aparatur ze skla v Biláru a v dalších předmongolských městech Volžského Bulharska i výzkum dílny alchymisty-klenotníka představují ojedinělý archeologický doklad existence alchymie ve Volžském Bulharsku na konci 12. až počátku 13. století. Zároveň dávají možnost zkoumat počáteční etapu rozvoje alchymie – experimentální chemie ve Východní Evropě.

Český souhrn Hedvika Sedláčková

Abbreviations

АКУ – Kazan University archaeological collection
БМ – Bilyar Museum
ГИМ – State Historical Museum

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