British Mission to Tell el-Amarna

Experimental manufacture of glass beads

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Experimental bead-making at Amarna, 2017, 2018

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The investigation of the courtyard of houses M50.14-16 in the Main City South in 2014 and 2017 brought forth some small fireplaces, which appeared to have been used for the manufacture of glass beads. A large number of unfinished beads, sometimes displaying trails of glass that had not fused properly or had not been polished off, were found near the fireplaces and all across the courtyard (Figures 1a, b).

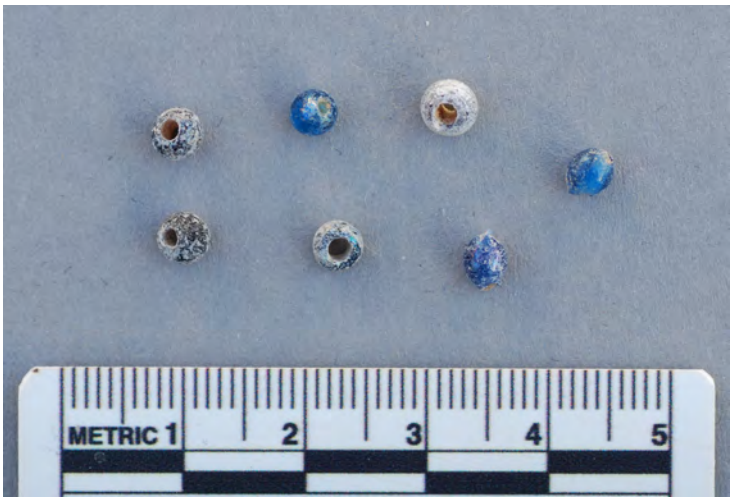

Figure 1a (left). *A group of unfinished (and weathered) glass beads from M50.14-16.*

Figure 1b (right). *An unfinished glass bead displaying trails of glass from M50.14-16.*

The ancient Egyptian method of bead-making is believed to have been very similar to the way modern beads are made: by means of the so-called lamp-working method, by which a rod of coloured glass is melted over a flame and wound around a metal rod-like *mandrel*. The ancient Egyptians would have probably made their beads over a small fireplace, using a narrow, very hot flame, and beads stuck to *mandrels* have been found at glass workshops at Amarna (Figure 1c). The fireplaces could have been very shallow and therefore not always recognised in the archaeological record, so that much information regarding ancient Egyptian bead-making technology will have been lost.

Figure 1c. *An unfinished glass bead on a* mandrel *(reconstruction) from M50.14-16.*

Coloured glass as used by both ancient and modern beadmakers requires a temperature of between 850 and 950° C in order to become sufficiently viscous and workable. In order to find out whether it was possible to achieve such temperatures, and subsequently to make glass beads over a small fireplace, which would not have left a significant trace in the archaeological record, Anna Hodgkinson and Miriam Bertram conducted a series of archaeological experiments, which took place in the area to the southeast of the excavation house at Amarna in 2017 and 2018.

The experiments were set up next to the large experimental kiln built by Paul Nicholson and Caroline Jackson in the 1990s, which had been modelled on one of the kilns excavated at workshop O45.1 in the Main City North. While the latter structure achieved extremely high temperatures, producing glass from raw materials at c. 1150° C, the present experiments endeavored to establish whether a well-ventilated, but much less substantial fireplace might be capable of achieving a similar temperature. The glass used in the experiments is modern glass, imported from Europe, as are the mandrels. Local acacia wood and charcoal were used as fuel, together with some lumps of dried dung, which were used for the initial firing.

Several approaches were necessary in order to achieve the ideal conditions for bead-making: the first fire pit was both too deep and too wide, resulting in an uncontrollable flame (Figure 2). The second attempt involved a brick-built structure, i.e. a clay-coated brick roof which covered a fire pit. However, less than ideal ventilation conditions resulted in this structure not achieving the required temperature.

Figure 2. *Miriam Bertram firing the first (unsuccessful) fire pit in late 2017, next to the experimental glass kiln (background, right) built by Paul Nicholson and Caroline Jackson.*

For the third experiment, in the spring of 2018, the village blacksmith, Kamal, from et-Till was present. He dug and constructed a clay-lined pit with a funnel-shaped superstructure. He attached and operated a pair of goat-hide bellows to this structure, and these provided the necessary ventilation. However, since the flame exiting the clay ring was not sufficiently hot, Kamal removed half of the kiln, enabling us to work directly above the flame (Figures 3, 4). This was the first time that temperatures in excess of 850° C were reached and beads were made (Figures 5a, b, c).

Figure 3 (left). *Blacksmith Kamal operating the goat-hide bellows while beads are being made above the flame of the semi-demolished kiln in early 2018.*

Figure 4 (right)*. A white glass bead being decorated with a dark blue thread during the first successful experiment in*

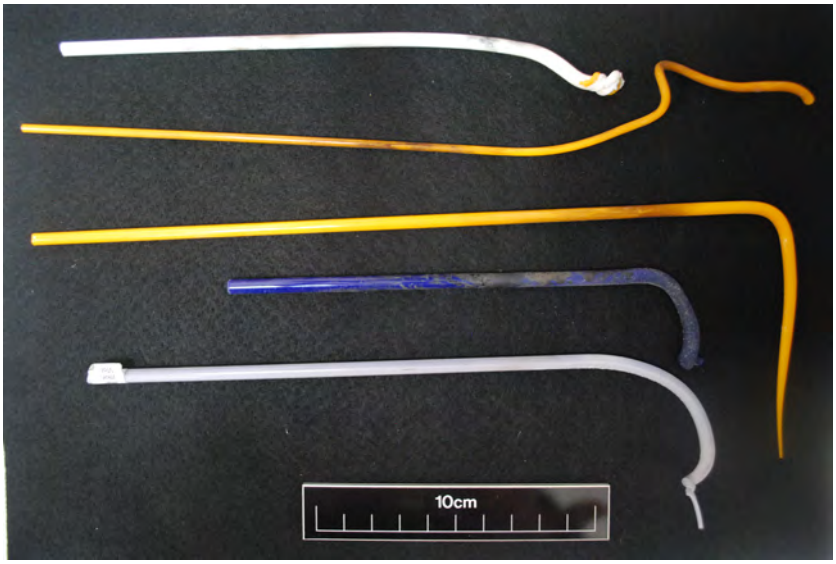

Figure 5a. *Colourful glass rods used in the first successful experiment, showing trails and bending, as well as scorching.*

Figure 5b. *By-products and bead wasters from the first successful experiment displaying tool marks.*

Figure 5c. *Imperfect beads resulting from the first successful experiment, some with traces of fly ash and vermiculite on the surface.*

Nevertheless, evidence of the use of bellows in ancient Egyptian glass-working is lacking in the archaeological record. The tomb of Rekhmire (TT100) includes a scene depicting the use of bellows, albeit in a metallurgical scene, and bellow attachments, so-called tuyères, are also known from metal-working contexts, including at Amarna. By contrast, the use of blowpipes to ventilate small bonfires, as attested in tomb scenes from the Middle Kingdom and New Kingdom (e.g. the tombs of Amenemhat and Khety at Beni Hasan, Figures 6a, 6b), creates a very narrow, well-ventilated spot in the fireplace, suitable for glass bead production, albeit involving a larger team of participants.

Figure 6. *Scenes from the tomb of Amenemhat at Beni Hasan (above) and Khety (below). Men, using blowpipes, ventilate a fire contained in a vessel (above) and an open fireplace (below). Photos A. Hodgkinson.*

For the most recent set of experiments which took place in the autumn of 2018, a small, shallow pit (c. 15cm deep and c. 40cm in diameter) was dug into the sand. Its base was lined with a (modern) Nile clay potsherd, and no further clay lining was applied (Figure 7). The fire was fueled by a mixture of small pieces of acacia wood and charcoal. Some dung and dry plant remains were used to start the fire. After only one hour the fire was sufficiently hot to bend, albeit not to melt, and work a glass rod.

In the first run, one, and during the second stage, two modern copper blowpipes, obtained locally in Mallawi, were operated by two participants, who blew in turns, providing constant ventilation for the fire (8). The blowpipes were covered with charcoal, but free from wood, and directed at a single spot, which soon reached 850° C, causing the tip of the glass rod to glow and enter a molten, viscous state. Thus, it was possible to melt and work the glass into beads by winding these glowing, soft ends around the metal mandrels which had been coated in a parting layer (Figures 9a,b, c, d). Some colourful polychrome glass beads with spiral and eye decoration were also produced (Figure 10).

Figure 7. *The fire pit being prepared for the most recent experiment; it is lined at the base with a potsherd, and a trowel has been placed next to it for scale.*

Figure 8. *Miriam Bertram and Cordula Werschkun ventilating the fire by means of copper blowpipes, Anna Hodgkinson preparing the glass.*

Figure 9a. *A dark blue glass bead being made: the molten glass is wrapped around the* mandrel. *The ends of the two copper blowpipes descend into the glowing charcoal.*

Figure 9b. *A finished dark blue glass bead on the* mandrel *with ash stuck to its surface.*

Although the ventilation by means of blowpipes provided more or less constant heat (whenever the fire did not require refueling), it also caused the ashes from the burning charcoal to fly up and stick to the glass, making the surface of some beads dull. Future experiments are planned, possibly without the use of charcoal, in order to counteract the flying ashes and, possibly, to test the manufacture of core-formed glass vessels over similar fire pits.

While these experiments do not teach us exactly the type of firing-structure or -pit the Egyptians used in the production of glass beads during the New Kingdom, it does give us a better idea and understanding of the logistics and difficulties involved in this type of production.

Figure 9c. *A dark blue glass bead being made: the molten glass is wrapped around the* mandrel.

Figure 9d. *A dark blue glass bead being decorated with a white thread above the fire.*

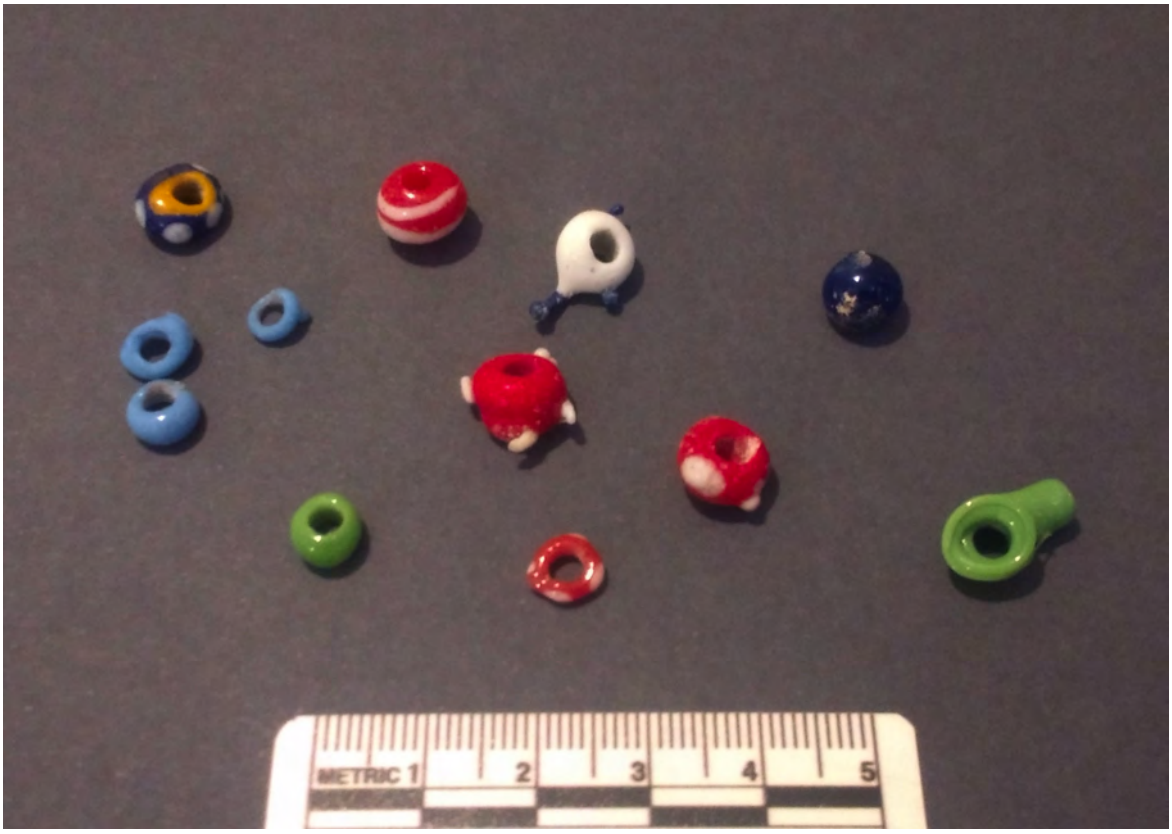

Figure 10. *Results from the most recent experiment: colourful glass beads, including some wasters.*