

RESEARCH ARTICLE – VÝZKUMNÝ ČLÁNEK

A unique stone mould for casting a spearhead from Morkůvky in South Moravia as an example of long-distance import in the Urnfield Period, and its technological contribution

Unikátní kamenný kadlub na hrot kopí z Morkůvek na jižní Moravě jako příklad dálkového importu v době popelnicových polí a jeho technologický přínos

Milan Salaš – Antonín Přichystal – Jan Petřík –
Karel Slavíček – Dalibor Všianský – Vojtěch Nosek

The paper provides a comprehensive analysis of a well-preserved half of a stone mould, accidentally found in the village of Morkůvky (Břeclav District). Although it is a stray find, it is characterised by above-standard informative value from the point of view of both typology and technology, as well as in terms of raw material provenance. According to macroscopic traces and XRF–XRD analyses, bronze was poured into vertically erected halves of the mould, which were tightened with copper wire. The negative reveals that the mould was used to cast a socketed lanceolate spearhead, in which each of the flanking blade wings and the midrib carried a longitudinal rib. This spearhead type is commonly found in the Carpathian Basin and is mostly dated to the Late Bronze Age. The area of its most frequent occurrence thus indicates the Carpathian origin of the mould, which was verified by petrographic analysis. According to its results, the casting mould is made of rhyolite tuff, i.e. a rock that occurs in adequate quantities in northern Hungary. The casting mould from Morkůvky is thus demonstrably the result of long-distance import and further evidence of Carpathian influences in the Middle Danube Urnfield Culture.

South Moravia – Late Bronze Age – spearhead – XRF/XRD analyses – petrography – material provenance – Carpathian imports

Příspěvek přináší komplexní analýzu unikátně dochované poloviny kamenného kadlubu, náhodně nalezeného v obci Morkůvky (okr. Břeclav). I když je to ojedinělý nález, vyznačuje se nadstandardní vypovídací hodnotou, a to z hlediska jak typologického a technologického, tak surovinově provenienčního. Podle makroskopických stop a XRF–XRD analýz byl do svisle postavených a měděným drátem stažených polovin kadlubu vléván cínový bronz. Dobře dochovaný negativ prozrazuje, že v kadlubu byl odléván hrot kopí s hruškovitě tvarovanou čepelí, žebírky profilovaným listem i žebírkem v listové části tulejky. Tento typ kopí je na Moravě přitom vzácný, běžně se vyskytuje v karpatské oblasti a většinou je datovaný do mladší doby bronzové (stupně B D–Ha A). Těžiště jeho územního výskytu proto také indikuje karpatský původ samotného kadlubu, což verifikovala petrografická analýza. Podle ní je odlévací forma vyrobena z ryolitového tufu, tedy horniny, která se v adekvátním množství vykytuje nejblíže v severním Maďarsku. Kadlub z Morkůvek je tak prokazatelně výsledkem dálkového importu a dalším dokladem karpatských vlivů v prostředí kultury středodunajských popelnicových polí.

jižní Morava – mladší doba bronzová – hrot kopí – XRF/XRD analýzy – petrografie – provenience suroviny – karpatské importy

Introduction

Casting moulds which provide evidence of metallurgical or metal-founding production are still relatively rare among the Bronze Age finds, and their number does not correspond to the enormous volume of bronze artefacts and bronze casts found. However, this disproportion is only apparent, distorted by the nature of the sources, the very material essence of the casting moulds, and the foundry technology. Solid, permanent moulds, mostly made of stone, rarely of bronze, were used repeatedly and allowed mass production. The otherwise certainly numerous, but mostly single-use clay moulds as well as moulds for the lost-wax casting are more difficult to identify in the pool of finds, and the technique of sand-moulded casting falls within the archaeology of the unfound (cf. e.g. *Merta 1978; Goldmann 1981; Weidmann 1982; Trommer – Bader 2013, 313–314; Lochner 2004; Jantzen 2008; Nessel 2019*).

The reliable identification of moulds is often negatively affected by their considerable fragmentation, both intentional technological and non-intentional post-depositional. This fragmentation can also complicate the typological determination of the cast artefact, which also applies to fragments of stone moulds. Another handicap of this type of finds is the state of their analysis and evaluation – for Bohemia and Moravia, we still lack a compendium that would catalogue and assess all the casting moulds known so far. Hundred pieces of casting moulds collected in north-western Bohemia were processed and evaluated in this way, and the authors indicatively recorded 186 moulds from all over Bohemia (*Blažek et al. 1998*). In recent years, at least indicative inventories of casting moulds, albeit without their typological determination, have appeared for some areas of Bohemia in studies by *Augustýnová (2016a; 2016b; 2017; 2018)*.

In Moravia, the finds of Bronze Age casting moulds are even less mapped. Some moulds from several sites interpreted as metallurgical centres (*Podborský 1974*) were indicatively recorded, but only the finds from Hradisko in Brno-Obřany (*Adámek 1961, 120; Kosarová 2009, 79–81*) and from Cezavy near Blučina (*Salaš 1985; 1995; Salaš et al. 2023, 344*) have been listed in more detail or assessed. Several sickle and axe moulds were recorded in the relevant volumes of the *Prähistorische Bronzefunde* series (*Říhovský 1989; 1992*). The only attempt at a comprehensive assessment of Moravian moulds from the Urnfield Period remains the master's thesis of *Kosarová (2009)*, in which 51 stone and lost moulds from 22 sites were collected, but only those related to the Middle Danube Urnfield Culture. However, the inventory certainly did not capture all the previously known finds. Also, the mould from the Brno-Špilberk site (*Kosarová 2009, 82–83* after *Salaš 1995, 570*) was recently reconsidered as medieval object (*Kostrhun et al. 2024, 164–166, obr. 10*). The current assemblage of the casting moulds from the Urnfield Period for the whole of Moravia can be estimated to be about three times as large as the cited list, according to published finds.

Most finds of casting moulds generally come from settlements, both fortified and open (*Salaš 1995, 570–572; Kosarová 2009, 83, tab. 2*). Much more rarely, moulds are found among grave goods (e.g. *Jockenhövel 2018*). It can be documented in Moravia by only two funerary assemblages – a pin mould in grave no. 177 in Určice (*Gottwald 1924, 60; 1931, 82*) and two moulds for tanged sickles at the burial ground in Moravičany, which were, however, used as part of the stone lining of a group of graves (*Nekvasil 1962, 58; 1982, 431, tab. 357: 1, 2; Jockenhövel 2018, 259–261, Abb. 24*). Relatively large numbers of

moulds occur in hoards, especially those with homogeneous contents, i.e. consisting only of casting moulds (e.g. *Nessel 2019*, 349–358). Nevertheless, in the case of older finds, lacking adequate documentation of the context, these might not be hoards *sensu stricto*, but rather unrecognised inventories of metallurgical workshops. An example is the Tetín 1 hoard, where the clay moulds (two cores and a hammer mould) were not part of the hoard itself, but were found together with fragments of daub in the ashy backfill of a pit, most likely used for workshop production (*Axamit 1924*, 19; cf. *Kytlicová 2007*, 248–249, 310, Taf. 141: 47–49; *Nessel 2019*, 355, 357, 732). Similarly, the set of 21 stone moulds from Zvoleněves belonged to contents of a settlement feature, probably used for production purposes (*Ernée – Smejtek 1997*). Among Moravian sites, Hradisko near Kroměříž, one of the sites with a higher concentration of finds of casting moulds (*Podborský 1974*, 70), can serve as a similar example. According to the manuscript by I. L. Červinka, ‘*in one pit, there were several sandstone moulds for a dagger, sickles, a ribbed bracelet, a pin, a star, and fragments of others*’ (*Červinka 1939*, 39), which indicates a workshop feature or production waste rather than a hoard.

If some finds of moulds are reported as stray and isolated finds (e.g. *Blažek et al. 1998*; *Nessel 2019*), then a closer examination of the settlement and topographic context would most likely prove their settlement origin, or a spatial relationship to a nearby settlement. This is also the case with the find of the mould from Morkůvky (Břeclav District) in South Moravia, to which this article is dedicated. It deals not only with standard typo-chronological or chorological analysis of the cast artefact, but also with some aspects of foundry technology, thanks to the exceptionally high-quality preservation of the mould with traces of intensive use. The unusual stone raw material, the petrographic analysis of which may indicate the provenance of the casting mould itself, also deserves special attention.

Circumstances of discovery, location and description of the find

The casting mould was found by J. Tomanec in 2007 during earthworks in the garden (plot no. 37/1) of his house no. 241 on the north-eastern edge of Morkůvky (*Fig. 1*). Here, it is said to have protruded with one corner to the current surface, but already in a tertiary position, because it was originally intended to be used secondarily in the stone foundations of a barn, standing in the north-eastern corner of the garden. The mould was most likely redeposited in modern times from an Urnfield Period site in the vicinity (*Fig. 1*; more details in the chapter Settlement and spatial context of the find). In 2019, the find was provided to the Moravian Museum by Z. Omelka from Hrušovany nad Jevišovkou for expert processing and in November 2024, it was transferred to the museum’s archaeological collection (inv. no. 215 933). Geomorphologically, the findspot of the mould is located on a gentle north-western slope at an elevation of 205 m above sea level on the right-bank terrace of the Haraska Stream on the eastern edge of the Diváky Highland district and the Boleradice Highland subunit, belonging to the Ždánice Forest from the subsystem of the Central Moravian Carpathians (*Bína – Demek 2012*, 277–278).

The find is represented by one half (valve) of a massive tabular casting mould made of rhyolite tuff, slightly trapezoidal in outline, with perpendicular circumferential lateral sides. The dividing plane is ideally flat, the opposite outer (dorsal) surface is slightly and irregularly arched with unevenly spaced transverse grooves 3–4 mm wide and red-coloured

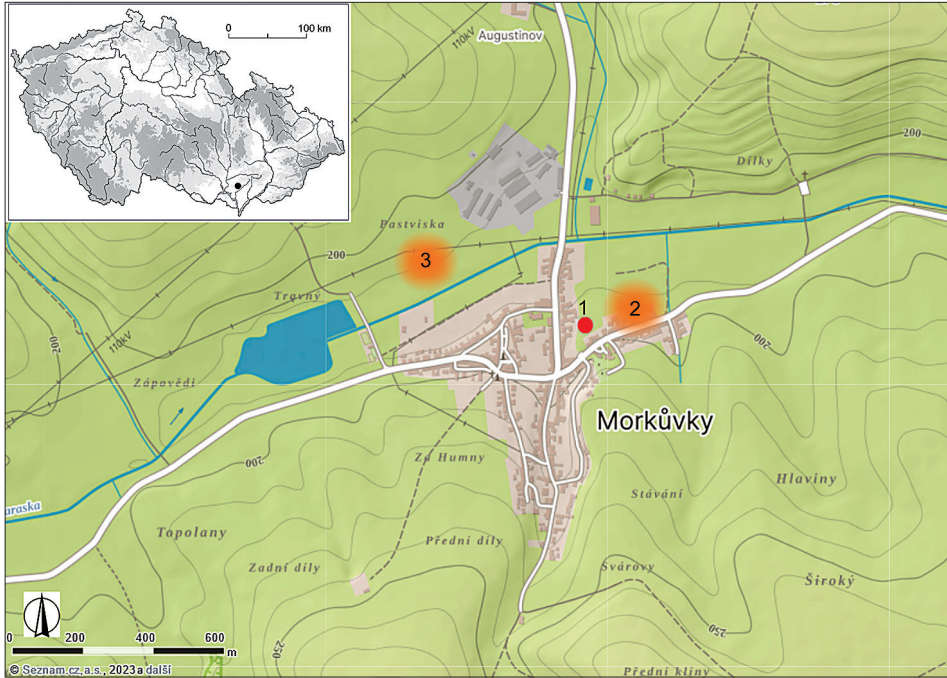


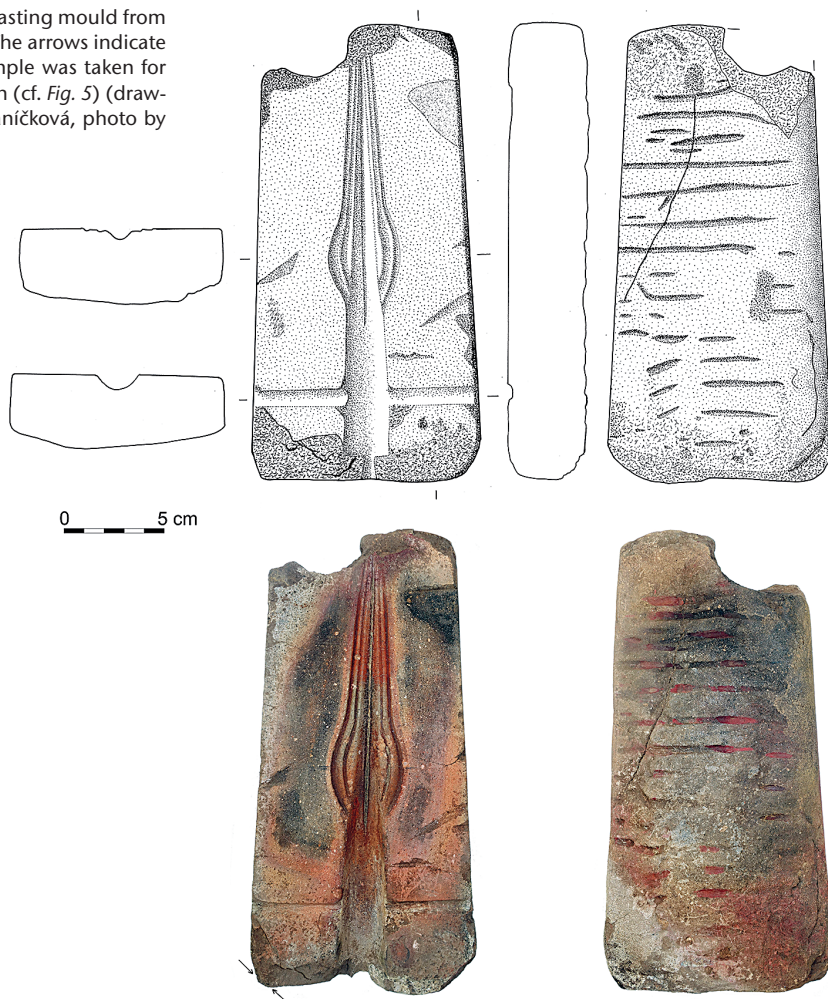
Fig. 1. Location of the find of a casting mould (no. 1) and Late Bronze Age sites (nos. 2, 3) in the cadastre of Morkůvky (Břeclav District).

inside. In the dividing plane, almost the entire negative of a socketed lanceolate spearhead has been preserved with longitudinal ribs on each of the flanking blade wings and on the midrib section of the socket. A groove for fixing the core with a rod chaplet runs across the free part of the socket and the entire width of the mould. One of the corners at the narrower end of the mould was broken off ages ago, and a sample for petrographic analysis was cut off the lower left corner at the wider end of the mould. Distinct traces of red, grey to black scorch or overburning are visible especially in the dividing plane. Inside the negative itself there are numerous transverse small cracks from overburning, on the corner of the outer side of the mould to the right of the socket and on the adjacent edge, the rock has been changed to glassy bubbly slag by overburning. The maximum length of the mould is 227 mm, the width ranges from 90 to 112 mm and the height from 28 to 40 mm. The preserved weight of the object is 1093 g (*Figs. 2–6*).

Morpho-typological and chrono-chorological analysis of the spearhead

Despite the evident signs of repeated and intensive use, the negative of the cast object is very well preserved and typologically easy to classify. The mould has been used for casting a socketed lanceolate spearhead with longitudinal ribs on the blade wings and a sharp rib on the midrib section of the socket (*Fig. 2; Fig. 3*). The same typological classification was

Fig. 2. The casting mould from Morkůvky. The arrows indicate where a sample was taken for a thin section (cf. Fig. 5) (drawing by A. Vaničková, photo by M. Salaš).



also verified by a virtual cast (Fig. 4). In Moravia, this rare type of spearhead is represented so far by only two fragmentary specimens, namely a blade fragment in the Drslavice 2 hoard (Říhovský 1996, 86–87, Taf. 19: 188; Salaš 2005, 72, tab. 163: 254) and an analogous fragment in the hoard from Polešovice (Salaš 1997, 33, Taf. 21: 527). The two assemblages of finds have in common both the dating to the Drslavice – Ořečov hoarding horizon, corresponding roughly to the later part of Reinecke's B D stage (Salaš 1997; 2005), and the spatial location in south-eastern Moravia, more precisely in the south-eastern part of the Zlín Region. The casting mould from Morkůvky with this type of spearhead is located a little further west, 36 km as the crow flies from Polešovice, but it is still the eastern half of the South Moravian Region. Morpho-typologically similar, but spatially somewhat different, is one of the spearheads in the Šebetov 5 hoard in Malá Haná region, which has a profiled blade and two small ribs on the midrib section of the socket (Jarůšková 2023, 241, obr. 25: 5). Except this hoard, the spatial location of the other Moravian specimens



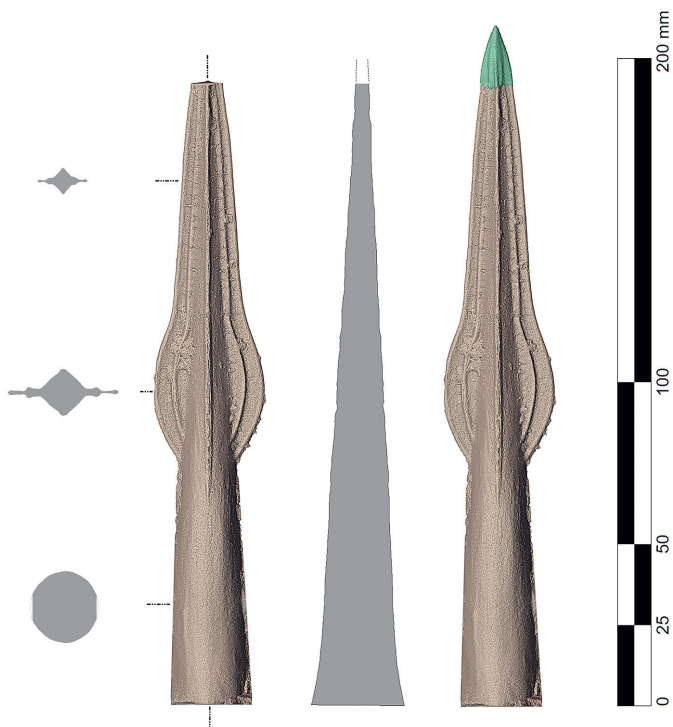
Fig. 3. 3D scan of the mould from Morkůvky (SfM – Agisoft Metashape). Rendered in Blender 4.2. For more details, see *Online Supplementary Material 1* (created by V. Nosek).

is not accidental. It is related to the territorial distribution of the mapped type of spearhead, especially in the northern part of the Carpathian Basin, where spearheads with one or more ribs on the blade and the socket, including the midrib section, are relatively common (e.g. *Hampel 1887*, Taf. 114: 11; 1892, táb. CXLIV: 34, 39; *Miske 1908*, Taf. XXX: 13; *Foltiny 1955*, Taf. 50: 9; 51: 6; *Kemenczei 1965*, XX. tábla: 3; *Novotná 1970*, Taf. 50: A6, 7; *Mozsolics 1973*, Taf. 51: 3; *Petrescu-Dîmbovița 1978*, Taf. 197: 980, 990; *Mozsolics 1985*, Taf. 3: 9; 4: 8, 9; 177: 8; *Říhovský 1996*, 63, 67; *Kobal 2000*, Taf. 31: A8; 34: B8, 10; 36: 27, 29; 48: 50, 51; 63: 22, 24; 89: 13; *Leshtakov 2015*, tab. 25: 5; 26: 1; 62: 7). However, an objective assessment of their occurrence is complicated by the fact that the ribs are difficult to identify in photos and sometimes even drawings, and without a profile drawing, they cannot always be distinguished from a rhomboid-sectioned socket (cf. e.g. *Mozsolics 1985*, Taf. 4; 5).

Morpho-typologically related are spearheads with a smooth blade and a socket profiled with one or more ribs. In Moravia, they are more numerous than the previous type of spearheads, but to the ten specimens registered already in 1994 (*Říhovský 1996*, 62–69), only three spearheads from the Polešovice hoard (*Salaš 1997*, 33, Taf. 20: 517; 21: 518, 519) and a spearhead from the Míchov 6 hoard in Malá Haná were added.¹ The share of this type

¹ For information about the as yet unpublished contents of the Míchov 6 hoard, we thank Mgr. Z. Jarůšková from the Museum of the Boskovice Region in Boskovice, where this hoard has been stored.

Fig. 4. Virtual cast of a spearhead from the mould from Morkůvky (yellow), supplemented by a missing fragment according to a scan of a spearhead of a similar shape (green) from Nemšová (Trenčín District, Slovakia). Rendered in Blender 4.2. For more details, see *Online Supplementary Material 2* (created by V. Nosek).



of spearhead in the total number of finds in Moravia is still around six per cent (cf. *Říthovský 1996*, 62). Also, in this type of spearhead, the centre of its distribution is located in the northern part of the Carpathian Basin, especially in the north-eastern part of Hungary and the adjacent areas of south-eastern Slovakia, Transylvania, and Transcarpathia, from where it sporadically spreads in the northern, western, and south-western directions (e.g. *Miske 1908*, Taf. XXXII: 7; *Kemenczei 1965*, XX. tábla: 4; *Mozsolics 1973*, Taf. 51: 4; 1985, Taf. 177: 7; *Vinski-Gasparini 1973*, tab. 77: 24; 97: 11; *Petrescu-Dîmbovița 1978*, Taf. 40: 2; 43: A4; 49: C14; 79: B15; 81: B12; 89: 26, 28; 102: 35, 37, 40, 41; 151: 403; 197: 984; 221: E7; 222: B2; 251: A20; *Chiodioșan – Soroceanu 1995*, 183, Abb. 1: 14, 15, 17; *Enăchiuc 1995*, 297, Abb. 2: 9, 11; *Říthovský 1996*, 63, 67, 86–87; *Kobal 2000*, Taf. 17: H4; 28B: 2, 3; 34B: 9, 11–12; 36: 26, 28; 38: B5; 39: 1, 2; 48: 49, 52–54; 51: 19–20; 81: 19, 20; 56: A19; 63: 23, 25; 65: A2; 87: C3; 96: 26–30; *König 2004*, Taf. 1: 6; *Gedl 2009*, 69–71; *Bader 2015*, 384–387; *Leshtakov 2015* with many examples).

The presence of spearheads with one or more ribs on the midrib section of the socket in Moravia can thus be considered the result of eastern to south-eastern, Carpathian, influences. For the dating of these forms, it is important that in all areas of their occurrence they are fixed by the find complexes mainly to the early phase of the Urnfield cultures, i.e. to stages B D–Ha A1, while spearheads with a smooth blade and a profiled socket are even rarely found in the Ha A2–Ha B1 stages (*Bader 2015*, 384–387; *Říthovský 1996*, 63, 65–67, 86–87). As regards the finds from Moravia, in the case of spearheads with both blade and socket profiled, and thus also in the case of the casting mould from Morkůvky, this is well confirmed by the above-mentioned hoards of Drslavice 2 and Polešovice.

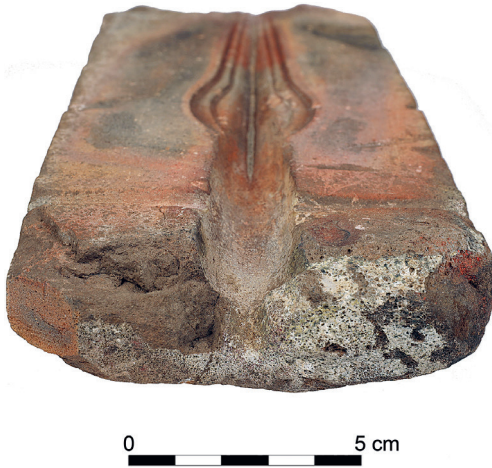


Fig. 5. Casting mould from Morkůvky. Detail of the surface on the basal lateral side of the mould around the mouth of the socket, on the left is the cutting surface for a thin section (photo by J. Cága).



Fig. 6. Casting mould from Morkůvky. Detail of the terminal lateral side with incisions (photo by J. Cága).

Spearhead moulds in Moravia, Bohemia, and neighbouring countries

Finds of spearhead moulds are relatively rare, much rarer than, for example, axe or sickle moulds. In Central Europe, this may be distorted mainly by hard-to-identify fragmented clay casting moulds, documented in more western areas (Weidmann 1982). Therefore, from the territory of Moravia and Bohemia, only a few pieces of stone casting moulds for spearheads are known to this day. In Moravia, two moulds of this type have been reliably documented so far. The first comes from a storage pit of the Lusatian Urnfield Culture in Bořitov. In its dividing plane, a part of the negative of a spearhead and a bracelet with longitudinal ribs has been preserved (Fig. 7: 1; Čížmář et al. 2000, 37, 129–130; Štřof 2000, 37; Kosarová 2009, 81, tab. V: 2). The second stone mould for spearheads is mentioned as a surface find from the ‘Příčnický’ site near Býkovice, also from a settlement of the Lusatian Urnfield Culture in the Boskovice Furrow (Kosarová 2009, 81; Štřof 2014, 167). The third stone mould could be represented by a fragment, which was in 1915 probably found among grave goods in Královopolské Vážany, today a part of the town of Rousínov (Procházka 1921, 28; in other literature erroneously as Vážany nad Litavou: Kosarová 2009, 82, tab. VI: 1; Podborský 1974, 71, tab. XII: 2), but the typological classification of its negative is not entirely reliable due to its fragmentation (Fig. 7: 2). Even less reliable and traceable is the casting mould from a settlement pit at the ‘Mezicestí’ site near Malenovice, which is supposed to have contained a negative of either an arrowhead or a short spearhead (Červinka 1939, 41). Thus, the spearhead from Morkůvky is only the third reliable and at the same time the best-preserved specimen of its kind in Moravia.

Judging by the published collections, the quantity of spearhead mould finds is not much better in most of the surrounding areas either. For example, in the entire original collection



Fig. 7. Stone spearhead moulds from Moravia. 1 – Bořítov (Blansko District, photo by Z. Jarůšková); 2 – Královopolské Vážany (Vyškov District, photo by J. Cága).

of casting moulds from north-western Bohemia, only two spearhead moulds are mentioned – from Třískolupy and Soběsuky (*Blažek et al. 1998*, 53, 152–154, Taf. 12: 60; 14: 65). Similarly, only two spearhead moulds were recorded from Lower Austria, namely an entire half of a mould from the Thunau am Kamp hillfort (*Lochner 2004*, 109, Abb. 2: 1) and both halves of a mould from another Urnfield Period hillfort near Stillfried (*Hellerschmid – Penz 2004*, 171, Abb. 9: 7; *Penz 2006*, 349, Taf. 18/3). In Slovakia, the find of an incomplete half of a casting mould from a strategically located settlement near Pobedim (*Studeníková – Paulík 1983*, 70, 139–140, 246, tab. XXXIV: 5) is geographically and culturally closest to Moravia. No other spearhead mould from the Urnfield Period is mentioned in the literature for Slovakia (*Pančíková 2008*); the moulds from Nižná Myšľa are chronologically older, from the beginning of the Middle Bronze Age (*Olexa et al. 2021*, 224–226, 236). These numbers of spearhead moulds for the countries under review are certainly underestimated, distorted by the state of research and processing of excavated assemblages. This can be demonstrated on significantly more numerous finds from, for example, Hungary (*Ilon 2006; 2022*) or Poland, where spearhead moulds are also found among grave goods (*Gedl 2009*, 79–80, Taf. 28–29; *Jockenhövel 2018*, 297).

Technology insights

The casting mould from Morkůvky is part of a classic and solid casting assembly for socketed metal artefacts (in addition to spearheads, also arrowheads, axes, or socketed chisels). These assemblies were usually three-part: two mirror-identical halves of the casting mould were complemented by a metal or clay casting core to create a socket. To fix the core, a needle or rod made of metal or organic material was used, which passed horizontally through the dividing plane of a vertically placed mould, crossing the free part of the socket

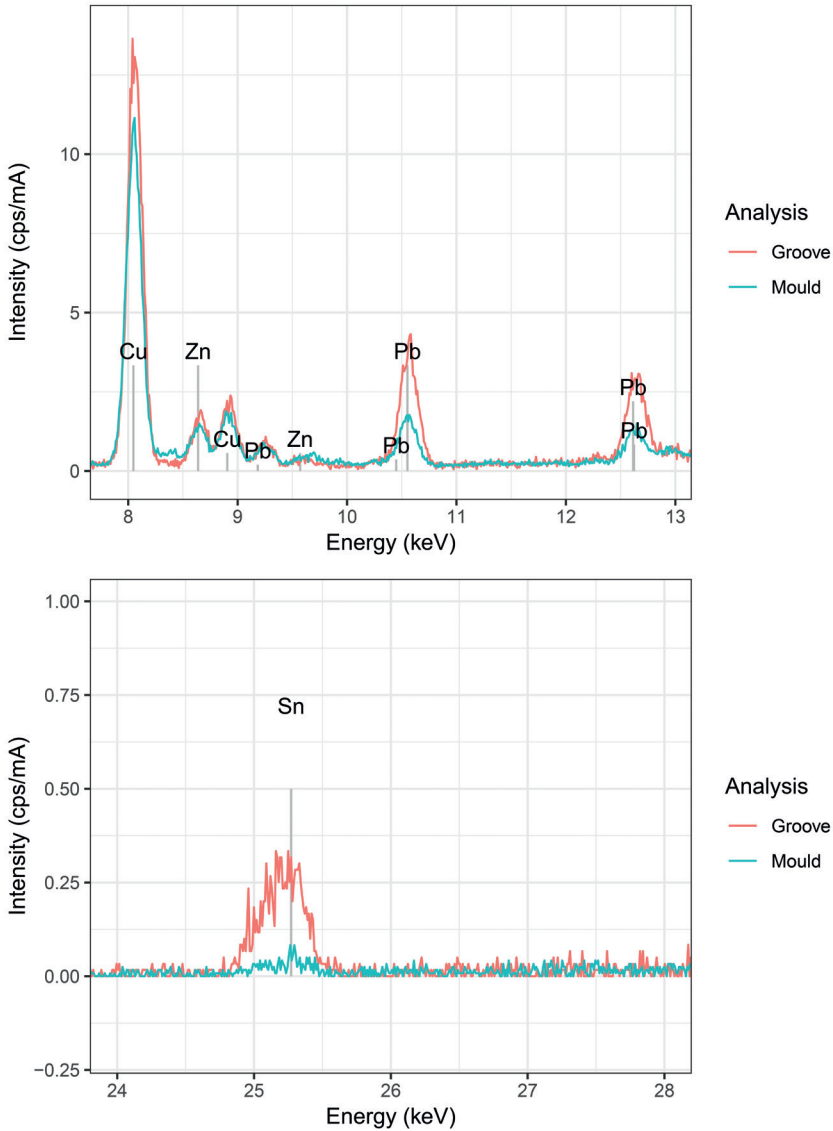


Fig. 8. Sections of the spectral record from XRF analysis documenting the enrichment with Cu, Sn, and Pb at the place of the inlet channel. Top – K-lines of Cu and L-lines of Pb (analysed with the secondary Mo target); bottom – $K\alpha_1$ -line of Sn (secondary Al target).

(cf. Tylecote 1962, 116; Hänsel 1990, 60–61, Abb. 3; 4: 1; 5: 5–6; 9: 1, 2, 5; Trommer – Bader 2013, 314–315; Nessel 2019, 167–169 and others). In the case of Morkůvky, it is well documented by the transverse groove for inserting a rod chaplet (Fig. 2; Fig. 3). The same grooves for fixing the core are common in other casting moulds as well (e.g. Blažek et al. 1998, 53, 152–154, Taf. 12: 60; 14: 65; Lochner 2004, 109, Abb. 2: 1; Leshtakov 2015, tab. 37: 6; 42: 11; 45: 9; 53: 1, 2; 76: A; 80: 5; 87: 4; 154: 2; Jockenhövel 2018, 256–257,

Tab. 1. Chemical composition of slaggy surface in the inlet channel of the mould. Analysis performed with a benchtop XRF spectrometer on powder samples (concentrations of the major oxides are given in wt.%, trace elements in ppm).

	Rock	Inlet channel
SiO ₂	77.6	69.9
Al ₂ O ₃	12.0	19.0
K ₂ O	5.4	5.7
Fe ₂ O ₃	3.1	2.7
CaO	1.4	2.4
P	217	1634
S	594	694
Ti	1127	1017
Cr	61	462
Mn	429	432
Ni	74	22
Cu	411	590
As	13	16
Rb	91	74
Sr	58	68
Sn	-	78
Pb	32	99

Abb. 21: 5; 22A: 7–8; Taf. 19: 29; 20: 31; 21: 32; *Overbeck 2018*, 121, Taf. 20: 31; 21: 32; 22: 33). By transverse fixation of the casting core, holes were created in the wall of the socket, which were later used to better fix the spearhead to the wooden shaft (*Trommer – Bader 2013*, 316).

The casting hole of spearhead moulds could be placed both on the side of the socket mouth and on the side of the tip of the spearhead (*Tylecote 1962*, 116, Fig. 25). It can usually be located in the mouth of the socket, and this is also the case with the mould from Morkůvky, where it is evidenced by the heavily burned, blistered or even slagged surface in the immediate vicinity of the socket mouth, as well as by the partially preserved groove of the sprue channel opening into the socket (Fig. 2; 3; 5). Here, slag-like crusts are preserved on the surface, the composition of which was examined on a benchtop ED-XRF spectrometer (Rigaku NEX-CG). Both the surface of the mould and the powder scraped off the surface of the sprue channel at the socket mouth with a scalpel were analysed. By comparing the content of silica, iron, and other components (K, Ca) between the rock itself and the surface of the channel, it was possible to prove local enrichment with non-ferrous metals in the inlet part of the mould. The measurements confirmed an increased proportion of copper (Cu) in the sprue channel and also detected tin (Sn) and lead (Pb), which indicate the presence of bronze (Fig. 8; Tab. 1). In the stone mass of the mould, these elements are found only in trace amounts. In accordance with macroscopic traces of overburning, XRF analyses clearly evidenced the repeated use of the mould for the production of tin bronze casts.

In the case of the moulds from Třískolupy and Soběsuky, bronze was also poured into the mould through the socket mouth (*Blažek et al. 1998*, 53, Taf. 12: 60; 14: 65) and similar inlet grooves in the socket also feature the moulds e.g. from Stillfried (*Penz 2006*, 349, Taf. 18/3), Legnica, Głubczyce (*Gedl 2009*, Taf. 28: 377, 382; 29: 383; *Jockenhövel 2018*, Abb. 21: 5; 22A: 7–8; Taf. 20: 31), or from other sites in Germany (*Overbeck 2018*, 121).

	Groove filling	Groove filling	Groove filling	Mould surface	Mould surface
S	0.4259	0.4841	0.4173	0.396	0.3535
K	5.6531	5.9836	5.3131	5.6659	5.4124
Ca	1.9883	2.0254	5.076	1.9401	2.2556
Ti	0.0791	0.0818	0.083	0.0956	0.0911
Mn	0.0343	0.0355	0.0837	0.0315	0.0373
Fe	1.085	1.1483	4.0277	1.1082	1.1913
Co	0.0083	0.0096	0.0199	0.0089	0.0112
Ni	0.0024	0.0085	0.0065	<LOD	<LOD
Cu	0.1942	0.4431	0.292	0.013	0.066
Zn	0.0036	0.0034	0.0945	0.0041	0.0034
As	<LOD	0.0022	<LOD	0.001	0.0017
Rb	0.0154	0.0154	0.0132	0.0143	0.0177
Sr	0.0083	0.008	0.0088	0.0087	0.0079
Zr	0.0127	0.0116	0.0099	0.0102	0.0105
Sn	0.0078	0.0129	0.1591	0.004	0.0068
Ba	0.0215	0.0226	0.0284	0.0205	0.0232
Pb	0.0142	0.0148	0.1729	0.0139	0.0113

Tab. 2. Chemical composition of the red-coloured substance in the grooves on the dorsal surface of the mould. Analysis performed with a handheld XRF spectrometer. Elements that were below the limit of detection or quantification were omitted from the table (the values are in wt.%; <LOD indicates values below the limit of detection).

On the other hand, the casting hole opening into the tip of the spearhead is documented by a mould from the Slovak site of Pobedim (*Studeníková – Paulík 1983*, 140, 246, tab. XXXIV: 5), and in Moravia by a mould from Josefov, which is, however, chronologically older, dated to the Věteřov Group (*Šrácková 1963*).

The local blistering or even slagging of the surface as well as various shades of red, grey or black overburning testify to high thermal stress associated with repeated and intensive use. This is also reflected in the small transverse cracks inside the negative itself, which are the result of sharp temperature fluctuations. Up to dozens of spearheads could have been cast in the mould, and it is even assumed that up to a hundred possible casts could have been made from a single stone mould (*Jantzen 2008*, 161; *Jockenhövel 2018*, 284).

Relatively rarely, incisions are preserved on the outer surfaces of solid moulds, mostly on their lateral sides, which are usually interpreted as traces of fixation, or tightening the parts of the mould, most likely with a wire (e.g. *Šrácková 1963*, 506; *Blažek et al. 1998*, 53, 119, Taf. 14: 65; 15: 81; *Leshtakov 2015*, 162; tab. 54 :4). Leather straps or plant fibres are also considered, but they would still have to be covered with a clay sheath (*Drescher 1957*, 59; *Jantzen 2008*, 161, note 128; *Overbeck 2018*, 204–205). In the case of the mould from Morkůvky, two distinct vertical incisions have been preserved on the otherwise mostly broken-off terminal side in front of the tip area (*Fig. 3*; *Fig. 6*). However, they are very sharp and narrow, so it is not possible to reliably assess whether they may be related to wiring or whether they are rather splicing marks (cf. *Ernée – Smejtek 1997*, 194; *Novotná 1957*, 317), especially since there are no holes for splicing pins on the dividing plane. Incisions were used as splicing marks on multi-part moulds in the production of not only spearheads, but also other types of bronze artefacts, e.g. socketed axes (*Wanžek 1989*, 40–44).

The irregularly spaced transverse, 2–4 mm wide, and locally distinctly red-coloured grooves on the dorsal side of the mould are a conspicuous and very probably a technological feature (*Fig. 2*). Both the grooves and their colouring are so specific or even unprecedented that it was desirable to subject them to a separate analysis. A combination of several analytical procedures was used to identify the material that fills the distinctive red-coloured grooves and to determine the chemical composition of the stone mould. In the first phase, indicative measurements were made, for 20 seconds each, at various points of the mould using a handheld XRF spectrometer set in the ‘soil mode’. This was done to determine, in particular, the occurrence of elements heavier than silicon. To obtain more accurate data on the stone body of the mould itself, a small sample (powder) was drilled off the central part in the place where a cutting sample for a thin section analysis had already been taken earlier. A small amount of powder for X-ray diffraction analysis (XRD) was also taken from the selected spot in the red filling of the grooves on the dorsal side of the mould. Analysis of the red coating from these grooves showed that it was predominantly an amorphous material with a noticeable proportion of copper and a trace amount of tin (*Tab. 2*). Especially compared to the surface of the mould, increased concentrations of Cu and Sn were proved, which corresponds well with the results of X-ray fluorescence. The results of these analyses, primary data and the script for creating the graph are stored in an external repository (*Slavíček et al. 2025*).

Petrographic analysis of raw material and its provenance

The magnetic susceptibility of the mould rock measured by the portable KT-6 magnetic susceptibility meter is not homogeneous, it probably changes with the nature of the affliction of the mould during firing. At the tip of the spearhead, it reaches only about 0.5×10^{-3} SI units on the dorsal surface and $1.5 - 1.7 \times 10^{-3}$ SI units on the ventral surface. On the lower side of the socket part, the values are higher (up to 2.8×10^{-3} SI units). It is probably related to higher temperatures and slagging.

Under a stereomicroscope, the original colour of the rock appears as light grey or originally reddish, and its crystalloclastic structure is clearly visible. Larger, sharp-edged fragments of whitish feldspars reach up to 1.5 mm, somewhat smaller are shards of quartz (about 0.5 mm), followed by flakes of black mica–biotite. The rock does not react with 5% HCl, and it is scratched by a steel needle.

A petrographic thin section was made from a rock fragment and studied under an Olympus BX-51 polarising microscope (*Fig. 9; Fig. 10*). The crystallo-vitroclastic structure is visible at first glance, with a predominance of fragments of clear glass measuring 0.1–0.2 mm, which appears isotropic (black) under crossed polars. Furthermore, distinctly shard-like fragments of feldspars are present, e.g. plagioclases with polysynthetic twinning, probably also alkali feldspars, and quartz crystals. Biotites have undergone baueritisation, which means that they have retained their characteristic cleavage, but they lack pleochroism. In some places, there are irregular accumulations of opaque mineral, which shine through brown at the edges. It is very likely a mixture of iron oxides and hydroxides referred to as limonite. Occasionally, round, larger fragments of bubbly or fluidic glass have been observed. The rock can be assigned to volcanoclastic (pyroclastic) sediments and classified as a sandy crystal-vitric tuff with biotite (see the classification in *Petránek et al. 1961*;

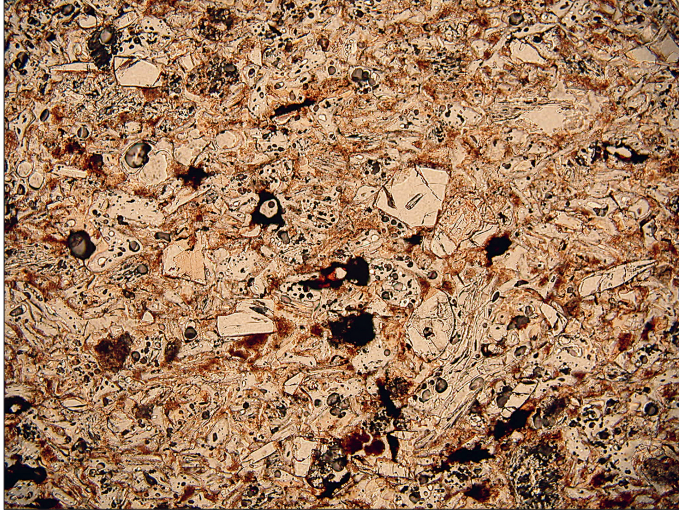


Fig. 9. Thin section of the raw material of the casting mould examined under a polarising microscope, plane-polarised light (image length 1.5 mm, photo by A. Přichystal).

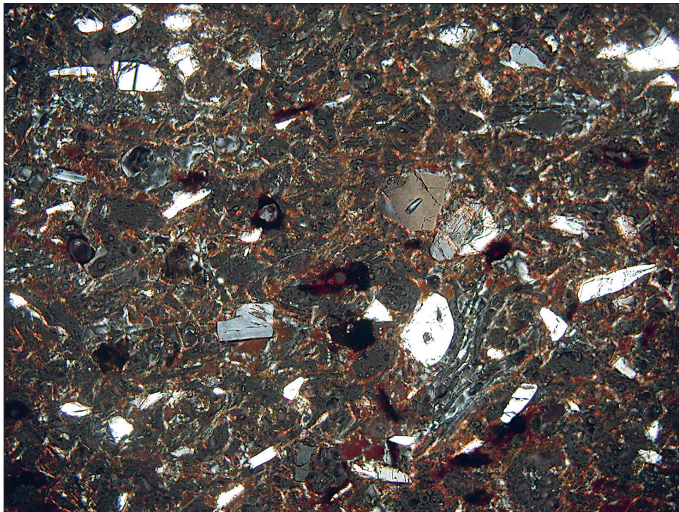


Fig. 10. Thin section of the raw material of the casting mould examined under a polarising microscope, crossed polars. The same part of the thin section as in Fig. 9 (photo by A. Přichystal).

Kukal 1985). The parent rock was undoubtedly acidic volcanite with a composition that corresponded to rhyolite or dacite.

X-ray fluorescence analysis was applied both to the red substance filling the grooves on the dorsal side and to the surface of the mould. Considering the elements important for classification, the content of potassium, which is 2.5–3 times higher than that of calcium (*Tab. 2*), indicates that the parent rock of the tuff was rhyolite. This is also largely confirmed by X-ray diffraction phase analysis (*Slavíček et al. 2025*), which, in addition to plagioclase, detected significantly represented potassium feldspar and mica minerals. Given the small transformation of the analysed rock, it is clear that it must be a rhyolite tuff of Tertiary age. We do not know the sources of such volcanism in Moravia, Silesia, Bohemia, or Poland; its closest occurrences are as far as the Western Carpathians in Slovakia and Hungary.

Acid tuffs of Miocene age form large areas in north-eastern Hungary with an overlap into southern Slovakia, so with the current state of knowledge, we are unable to determine the specific place of origin of the raw material of the casting mould. Preliminarily, it seems likely that it might be the so-called Gyulakeszi Rhyolite Tuff from northern Hungary (with its outcrops mainly near the town of Salgótarján or in the south-eastern vicinity of the Bükk Mountains), which originated in the Late Tertiary at the Eggenburg/Ottmang boundary and is supposed to be 19.6 ± 1.4 million years old. Its thickness in the mentioned area reaches up to 100–200 m and it forms conspicuous formations called ‘fairy chimneys’ or ‘beehive stones’ (*Budai – Gyalog 2010*). Similar formations are known from Cappadocia in Turkey.

Settlement and spatial context of the find

The current location of the casting mould is almost certainly the result of repeated recent redeposition. This is evidenced not only by the original use of the mould in the stone foundation of the former barn, but also by the fact that no prehistoric finds are known from the given plot or from the immediately adjacent plots. However, at least two sites of the Urnfield Period are documented both directly from the inner built-up area of the village and from other parts of the cadastre. The closest to the findspot of the mould is a settlement from the Velatice phase of the Middle Danube Urnfield Culture, located on the eastern edge of the village on the right-bank terrace of Haraska stream (*Unger 1985*, 20–21). Fragments of settlement pottery were discovered here during construction of houses nos. 212 and 222 in the 1970s (*Fig. 11: 1–4*). A bronze pin was also allegedly found on the site of house no. 212 (*Unger 1985*, 21). Its stem probably passes into a ring-shaped head with a plano-convex cross-section, but only its lower arched segment (*Fig. 11: 5*) has been preserved. The ends of the segment are probably not fractured, but rather unfinished, so it could be a defective casting. Therefore, it is not possible to classify the pin with sufficient certainty as a ring-headed pin, which is dated to the Early Bronze Age (e.g. *Tihelka 1953*, 270; *Zich 1996*, 202–203, 647; *Bartelheim 1998*, 70–71, Taf. 46: T12; *Moucha 2005*, 52) and whose ring has a circular cross-section, unlike the specimen from Morkůvky. The pin, thus, cannot be reliably classified and used for chronological considerations. Moreover, its finding context is unclear as well as the relationship to the assemblage of Velatice pottery. The pin could be related, for example, to settlement finds of the Únětice Culture identified in the north-western part of the cadastral municipality of Morkůvky on the left-bank terrace of Haraska stream in the Pastviska site. Other sites of the Únětice Culture are known from the neighbouring cadastral municipalities of Boleradice and Brumovice (*Skutil 1939*, 18–19; *Unger 1984*; *Klanicová 1993*, 2; *Geisler 1996*, 91).²

The second settlement site of the Middle Danube Urnfield Culture was recorded in the above-mentioned Pastviska site (*Fig. 1: 3*). Here, a part of an amphora-shaped bowl, typical of the Velatice phase of Middle Danube Urnfield Culture, was accidentally found in 1978 (*Fig. 11: 6*). The distance of this site from the findspot of the casting mould is about 450 m,

² The mentioned finds from Morkůvky are stored in the Regional Museum in Mikulov. We thank Mgr. F. Tramptová, Ph.D. for information about unpublished finds.

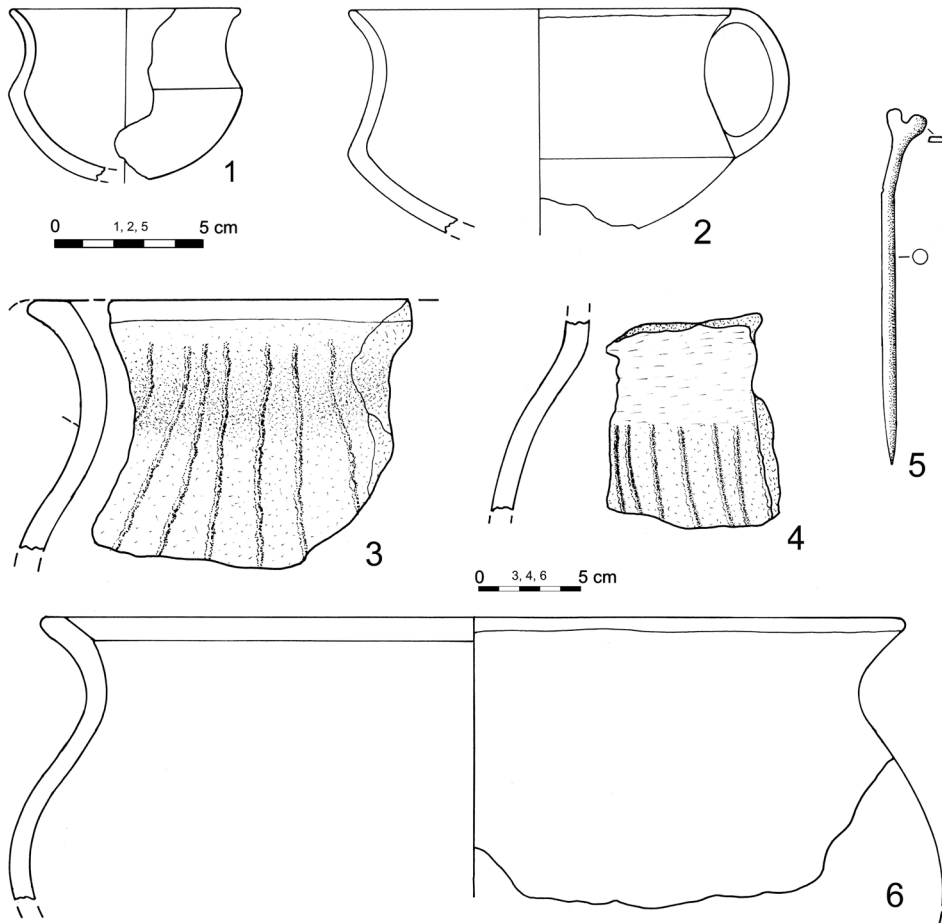


Fig. 11. Morkůvky. 1–4 – pottery of the Velatice phase of Middle Danube Urnfield Culture from a settlement in the eastern part of the inner built-up area of the village (no. 2 in Fig. 1); 5 – bronze pin from house plot no. 212 on the eastern edge of the village; 6 – settlement pottery from the ‘Pastviska’ site in the north-northwest part of the cadastre (no. 3 in Fig. 1) (collection of Regional Museum in Mikulov, drawing by A. Vaničková).

while the distance to the nearest settlement finds of Middle Danube Urnfield Culture in the eastern part of the built-up area of the village, or the finds at house no. 222, is only about 115 m. Therefore, the spatial connection of the mould with this settlement is highly probable.

Discussion

Among the most remarkable technological attributes of the casting mould are the grooves on its dorsal surface and their red colouring. The connection between the grooves and the fixation and tightening of both valves of the mould is beyond all doubt. Nevertheless, the

interpretation of the red coatings, for which no analogies have been found, is somewhat more problematic. At first, our considerations were directed towards the application of red dye as a ritual part of the casting process, but after the elemental composition analyses showed an increased copper content in the red coatings, we interpret them as traces of tightening the halves of the casting mould with copper wire.

In addition to technological knowledge, a remarkable aspect of the casting mould is its allochthonous provenance. The cast type of spearhead with ribs on the blade and on the midrib, as well as the rock used, which is classified as rhyolite tuff, testify to the Carpathian origin of this casting mould. The locally limited occurrence of rhyolite tuff allows us to search for the origin in the area of northern to north-eastern Hungary. In this northern part of the Carpathian Basin, tuff was quite commonly used for the production of casting moulds in the Bronze Age due to its advantageous properties. Petrographic analysis of 125 moulds showed that nine of them were made of tuff from Hungary (*Bálint 2004*). Another example may be the casting moulds from the eastern Slovak fortified site of Nižná Myšľa, where about half of the forty moulds found, including spearhead moulds, are made of local tuffs (*Olexa et al. 2021*, 224–225, 236). In the Czech lands, this is the first evidence of using such a stone raw material, moreover, an imported one, for a casting mould in the Bronze Age.

When locating the outcrops of the raw material used in the northern part of the Carpathian Basin, or roughly in the vicinity of Salgótarján, it is about 250 km as the crow flies to the findspot in Morkůvky. The travel distance would be at least 100 km longer. The casting mould from Morkůvky is thus another reliable and eloquent evidence that the long-distance transport of raw materials used for the production of stone moulds could reach tens to hundreds of kilometres (*Ernée – Smejtek 1997*, 197–198; *Jockenhövel 2018*, 280–282; *Overbeck 2018*, 200–201). Similarly, up to hundreds of kilograms of copper ingots, contained mainly in hoards of the Middle to Late Bronze Age, were transported to Moravia by long-distance transfer as another type of raw material. Illustrative and convincing evidence of the long-distance transport of final artefacts in the Urnfield Period can be the ceramic vessels with chip-carved decoration at Cezavy near Blučina, originating from as far as the Upper Danube region (*Salaš et al. 2023*, 256–257).

If distances of up to hundreds of kilometres are to be overcome, the mould would probably be transported as a final product rather than a rough piece of stone raw material (similarly, for example *Ernée – Smejtek 1997*, 197–198). The import of a finished mould is also indicated by the fact that the cast type of spearhead is not commonly found in Moravia; it is not autochthonous here. On the other hand, it is common in the Carpathian Basin and in regions where the given raw material naturally occurs. If a block of rock was imported, then in the new environment, in this case in South Moravia, it would most likely be used for the production of another, more autochthonous type of spearhead.

The casting mould testifies to direct or mediated contacts between the Middle Danube Urnfield Culture in South Moravia and the cultural complex of the South-Eastern Urnfields, most likely the Carpathian Piliny Culture or Suciú de Sus Culture. If we take into account other, relatively numerous manifestations of intra-Carpathian influence, particularly evident in the Drslavice 1–2 and Polešovice hoards (*Salaš 1997; 2005*, 219), it is clear that in the early stage of the Urnfield Period (B D2–Ha 1) there was a cultural and probably partly migratory diffusion from the area of the Carpathian Basin westwards beyond the arc of the White Carpathians.

The casting mould shows indisputable macroscopic traces of repeated and intensive use. This raises several questions. First of all, to what extent the mould was used for the production of casts in the original, i.e. Carpathian, environment and whether and to what extent it was still used in practice in the environment of the Middle Danube Urnfield Culture in South Moravia. Of course, the latter cannot be completely ruled out, but if so, then the entire casting assembly, including both the mould and the core, would have to be imported. Importing only half of the mould would have no practical sense, except perhaps as an object of ritual practices or a rarity.

If the imported casting mould was used in practice in a new destination, the question would arise as to how to assess the cast spearhead from the point of view of cultural provenance. It would be an autochthonous, local product, so it would not be a direct Carpathian import, but even so, with regard to the spatial occurrence of the given spearhead type and the origin of the casting mould, it would still be the result of Carpathian influences.

Conclusion

Although the stone spearhead mould from Morkůvky is a recently redeposited object, torn out of the original settlement context, its informative value exceeds the standard of most similar artefacts. Despite minor and probably recent damage, it is one of the best-preserved halves of casting moulds of this kind in the Czech lands. It shows indisputable macroscopic traces of repeated and intensive use associated with thermal stress. Judging by the working traces that were examined using the X-ray fluorescence and X-ray diffraction analyses, tin bronze was poured into the vertically placed halves of the mould tightened with copper wire, through a sprue channel opening into the socket of the artefact. According to the perfectly preserved negative, the cast artefact can be reliably and accurately typologically classified as a socketed lanceolate spearhead with ribs on the blade and the midrib. In Moravia, this type has been evidenced only by one piece each in the Drslavice 2 and Polešovice hoards, which, together with other assemblages of finds outside the territory of Moravia, prove its dating and thus the dating of the mould itself to the early phase of the Urnfield cultures.

From a chorological point of view, it is significant that both hoards containing this type of spearhead are located in south-eastern Moravia near the arc of the White Carpathians. The centre of distribution of this type is the northern part of the Carpathian Basin, so their currently-known Moravian finds are located at the western periphery of this area. If these spearheads in Moravia are the result of Carpathian influences or directly Carpathian imports, then the origin of the casting mould can also be sought in the Carpathian Basin on the basis of its typological classification. This provenance is uniquely verified and refined by petrographic analysis of the raw material used for the casting mould. It is rhyolite tuff of Tertiary age, which does not occur in the Czech lands. The nearest suitable petrographically adequate outcrops of this raw material are found in northern Hungary, especially in the surroundings of Salgótarján or in the south-eastern vicinity of the Bükk Mountains. With regard to its typological classification and raw material provenance, the casting mould from Morkůvky is, alongside some types of bronze artefacts, especially in the Drslavice 1–2 and Polešovice hoards, another eloquent evidence of Carpathian diffusion into the western neighbourhoods.

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MILAN SALAŠ, Institute of Archaeology, Moravian Museum, Zelný trh 6, CZ-659 37 Brno; msalas@mzm.cz
ANTONÍN PŘICHYSTAL, Department of Geological Sciences, Faculty of Science, Masaryk University, Kotlářská 2, CZ-611 37 Brno; prichy@sci.muni.cz
JAN PETŘÍK, Department of Geological Sciences, Faculty of Science, Masaryk University, Kotlářská 2, CZ-611 37 Brno; petrik.j@sci.muni.cz
KAREL SLAVÍČEK, Department of Geological Sciences, Faculty of Science, Masaryk University, Kotlářská 2, CZ-611 37 Brno; slav.karel@sci.muni.cz
DALIBOR VŠIANSKÝ, Department of Geological Sciences, Faculty of Science, Masaryk University, Kotlářská 2, CZ-611 37 Brno; dalibor@sci.muni.cz
VOJTĚCH NOSEK, Department of Archaeology and Museology, Faculty of Arts, Masaryk University, Arne Nováka 1, CZ-602 00 Brno; vojtechnosekuam@gmail.com