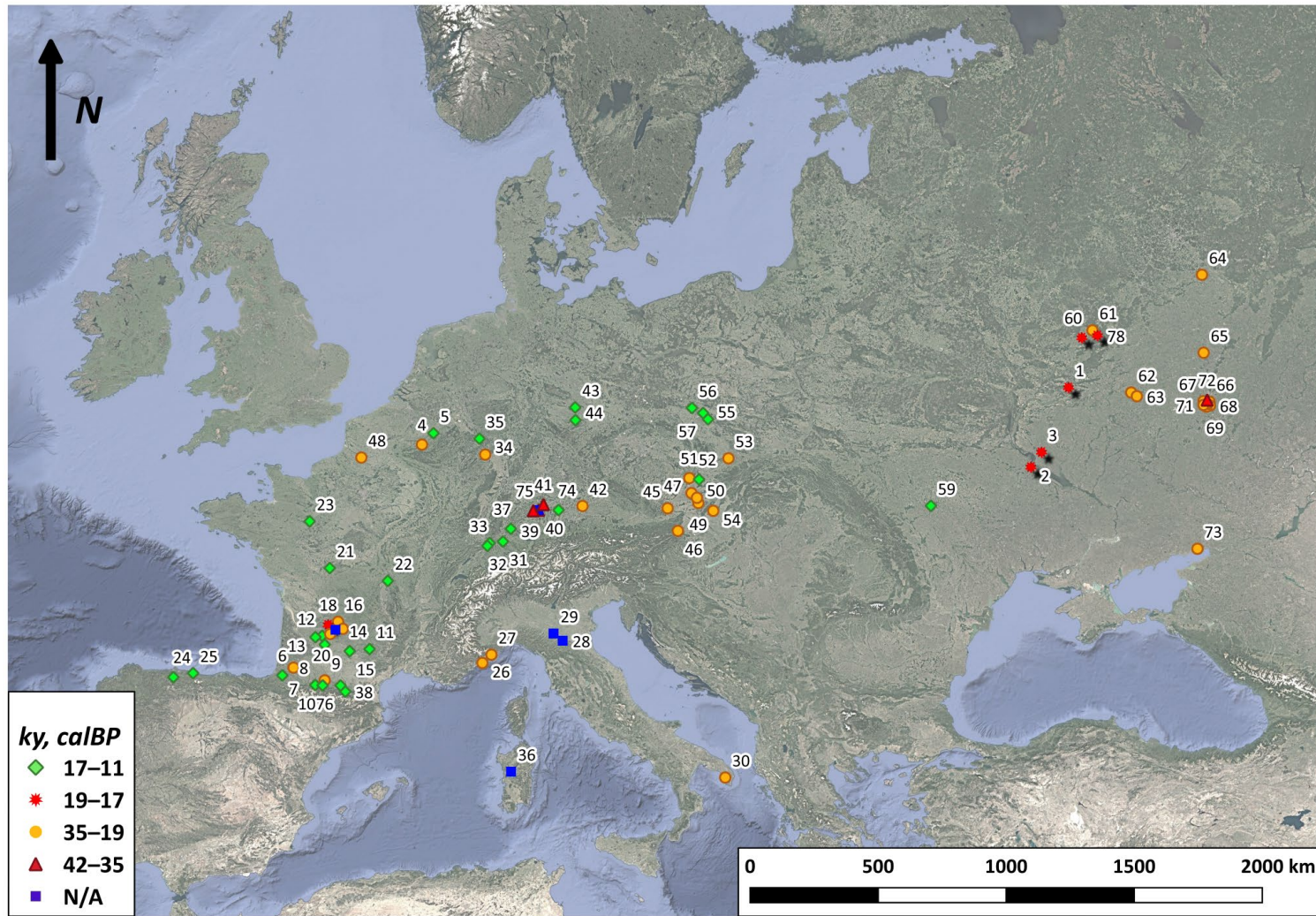
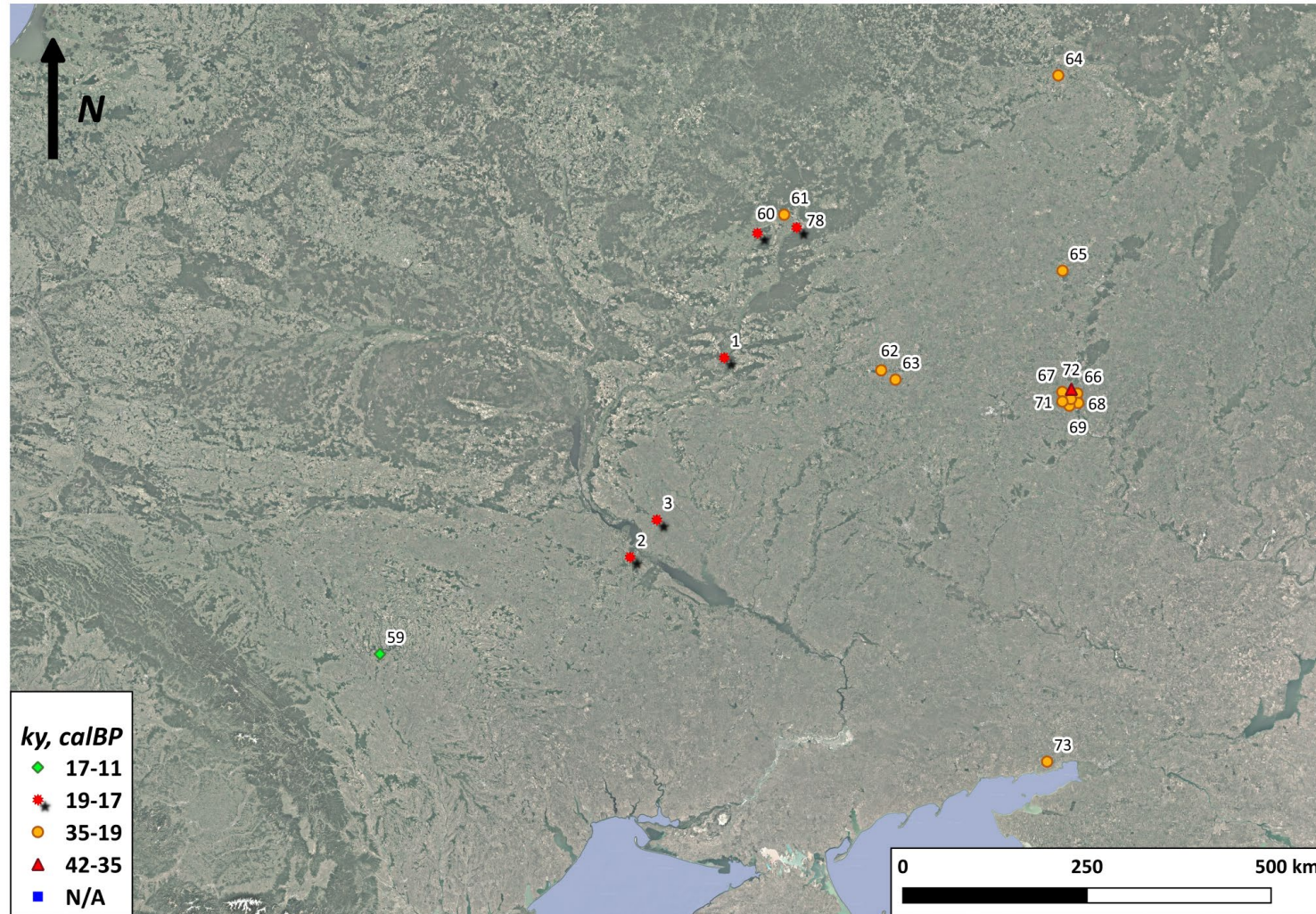


Supplementary 1

Chronological attribution of Upper Paleolithic female figurines in Europe



Supplementary Figure 1. Location map of European Upper Paleolithic sites with female figurines. Red triangles mark figurines attributed to the chronological interval of 42–35ky calBP; orange circles mark figurines attributed to 35–19ky calBP; Red stars mark figurines attributed to 19–17ky calBP; green diamonds mark figurines attributed to 17–11ky calBP; blue squares mark figurines without clear chronological attribution



Supplementary Figure 2. Location map of Eastern European Upper Paleolithic sites with female figurines. Red triangles mark figurines attributed to the chronological interval of 42–35ky calBP; orange circles mark figurines attributed to 35–19ky calBP; Red stars mark figurines attributed to 19–17ky calBP; green diamonds mark figurines attributed to 17–11ky calBP; blue squares mark figurines without clear chronological attribution

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Supplementary 2

The Cultural and Chronological Attribution of the Mizyn site

The excavations at Mizyn were carried out in 1907 by Kvedir Vovk (Volkov 1913) and continued by Petro Yefymenko, Levko Chykalkenko, Mykhailo Rudynskyi, and Ivan Shovkopliias (Chernenko 2008); the site was fully excavated in 1908–1916, the 1930s, and the 1950s (Tseunov 2015). Excavations uncovered four dense concentrations of mammoth bones and associated archaeological materials, interpreted as “mammoth bone dwellings” (Shovkopliias 1965). In the case of earlier excavations, these were initially reconstructed post hoc based on early field documentation (Sergin 1987). Despite the limitations of the fieldwork, particularly the insufficient recovery of microartifacts, excavations at the Mizyn site revealed a significant lithic assemblage, comprising over 113,000 objects (Shovkoplyas 1965). The material was found in concentrations and pits, interpreted as areas where knapping occurred. The assemblage is technologically and typologically distinctive, characterized by microgravette points, backed microblades, endscrapers, and various types of burins (Nuzhnyi 2015). The reduction strategy reflects the use of freehand hard-hammer technique to produce blade blanks along two distinct trajectories: one for manufacturing “household” tools and another for specialized hunting implements (Dudnyk 2024).

The history of interpretations of the Mizyn site largely consists of its attribution to a particular taxonomic unit – a technocomplex, a stage of the Paleolithic periodisation, or a named archaeological culture (NAC). These attributions or re-attributions are reminiscent of a card game with the shuffling of a small (less than a deck of cards) set of well-excavated Late Upper Paleolithic sites in the centre of the East European Plain (Reynolds & Riede, 2019). Modern studies highlight the problematic nature of this approach, as an additional layer of named archaeological cultures may obscure or diminish the multidimensional archaeological reality of specific material culture complexes. Accordingly, we will attempt to present the current state of affairs, with limited historiographical excursions. The interested reader may find quite comprehensive overviews of historiography in recent works (Chabai et al., 2020; Demidenko YE, 2020).

Mizyn is an Epigravettian site and this technocomplex unites most of the Late Glacial sites in the centre and south of the Eastern European Plain (Anikovich, 1998). However, it is distinguish the Epigravettian of the Mediterranean basin (Broglia, 1972; Cohen, 1999) and the synchronous Epigravettian sites of central Europe, which bear significant differences (Olenkovskiy, 2010), with Mizyn conforming to the latter. A characteristic feature of the east and central European Epigravettian is the variety of lithic projectile heads based on a backed bladelet (Nuzhnyj, 2008). Mizyn is one of the earliest manifestations of Epigravettian in the centre of the Eastern European Plain (Soffer, 1985), although earlier dated Epigravettian sites

are known to the south, in the modern steppe zone near the Black Sea (Stanko & Svezhentsev, 1988).

Another option for attributing Mizyn is to refer it to the Magdalenian. When it was first articulated, it was obviously about the Magdalenian as a stage of the Paleolithic periodisation (Chykalenko, 1923; Efimenko, 1913; Volkov, 1913). Subsequently, the use of this term was more likely to refer to Mizyn art alone, rather than to the complex of material culture as a whole (Abramova, 1988, 1995). Recently, Yurii Demydenko has drawn attention to a number of ‘Magdalenian-smelling’ features of Mizyn and several other nearby sites (Demidenko YE, 2020). However, they remain insufficient to replace the Epigravettian attribution of this site and cultural convergence in similar environmental conditions or of distant contacts between cultures cannot be excluded.

Mizyn was understood as a reference site for a certain group of sites: fitting into the Late Upper Paleolithic, with mammoth bone structures (interpreted as “dwellings”), with a rich bone and ivory industry, and some instances of portable art. These sites were united into the Mizyn culture (Shovkoplias, 1965), also called Mezinien (Iakovleva, 2009). However, the unity of these sites was questioned on the basis of statistical differences in the typological composition of lithic assemblages (Gladkykh, 1971; Gvozdozer & Rogachev, 1969). However, it is increasingly clear that this entity is genuine, but that its common characteristics instead stem from a shared peculiar landscape and adaptation model (Zaliznyak, 1998). This larger entity was named the Dnieper-Don cultural and historical region of mammoth hunters and understood as a multicultural realization of an ideal economic and cultural type (*hospodarsko-kulturnyi typ*, HKT) of ‘mammoth hunters’ (Anikovich, 1998; Stanko et al., 1999).

While, from the point of view of environment and adaptation, Mizyn is the brightest representative of this group of sites, there are possibilities of its finer typological characterization. Namely, it has currently been accepted that the Epigravettian ‘mammoth hunters’ sites of the Central East European Plain can be subdivided into several taxons, named industries, each uniting several sites with certain shared typological and technological features of their lithic inventories (Nuzhnyi, 2015; Nuzhnyj, 2002; Olenkovskiy, 2008). Mizyn is usually grouped with sites of Rivne-Barmaky and Borschevo 1 into ‘Mizyn industry’ (Nuzhnyi, 2015). The shared typological traits include peculiar types of microlithic projectile heads: a backed bladelet with obliquely retouched base (points of Mizyn type) and so called atypical ‘*points a cran*’, as well as certain features of burin group composition. Some other features of their material culture are also surprisingly similar: for example, finds of mammoth ivory bracelets in Mizyn and Rivne-Barmaky. For this fine typological classification outsider groups

are Mezhyrich (Nuzhnyj, 2002), Ovruch, and Yudinovo industries as well as some other stand-alone sites (Chabai et al., 2020).

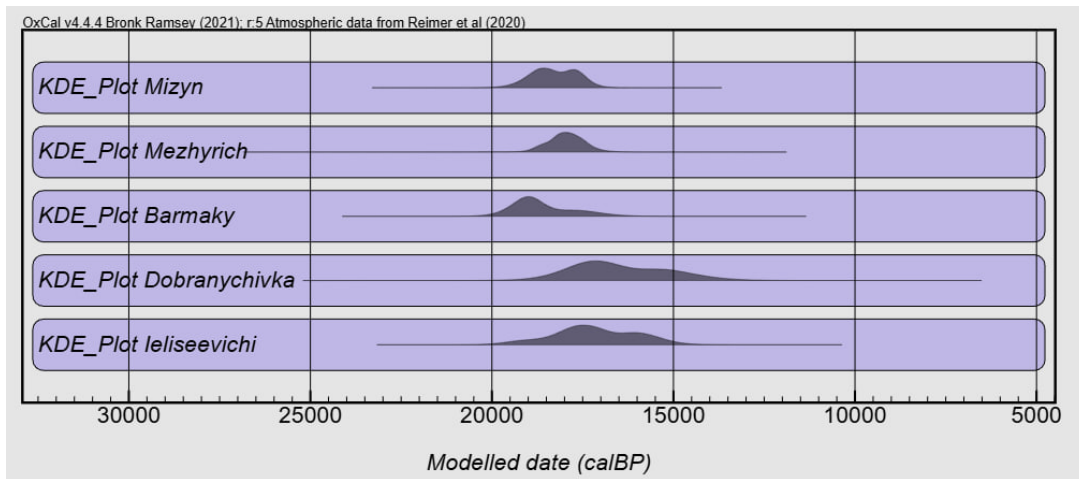
Thus, within the systematics of the Late Paleolithic in Eastern Europe, Mizyn can now be referred to as representing the Mizyn industry of the Epigravettian techno-complex (sometimes specified as the classical variant, following Olenkovsky 2002), belonging to the Dniro-Don region of 'mammoth hunters.'

In total, nine radiocarbon dates have been taken from material attributed to the Mizyn site so far. Initial efforts yielded unacceptably early estimates for its age (Demidenko YE, 2020). There are three AMS and two conventional dates obtained recently (Chabai et al., 2020), which provide a new estimate of 19480-17382 calBP. There was a suggestion of their bimodality, which could indicate two episodes of habitation on the site (Chabai et al., 2020), however evidence for this remains exclusively indirect.

Another site belonging to the Mizyn industry: Rivne-Barmaky yielded four dated bone samples. They are somewhat earlier than the accepted chronology for Mizyn (Chabai et al., 2020). However, they can be calibrated to 19378-16905 calBP, thus being largely synchronous with Mizyn dating.

The Mizyn industry is roughly contemporaneous with two other taxonomic units of Epigravettian of the Central East European Plain: Mezhyrich and Yudinovo in the timespan of 18500-17000 calBP (Chabai et al., 2020). The Mizyn site itself is statistically synchronous with the other portable art bearing sites: Mezhyrich, Ielissevichi and Dobranychivka.

Typological considerations made by many authors suggest that the Mizyn lithic industry is earlier than the lithic industries of Mezhyrich and Dobranychivka (Anikovich, 1998). The development of the female image in the portable art suggested another ordering of the sites: with Mezhyrich being the earliest and Mizyn – the latest (Jöris, 2021). We can check these hypotheses and try to look for the ordering of these sites. Discarding evidently non-relevant dates, we arrive at the following conclusions.



Supplementary Figure 3. Kernel density Estimates (KDE) plotted for relevant Epigravettian sites of the Central East European Plain

The Kernel Density Estimates (KDE, (Bronk Ramsey, 2017)) for the sites under comparison reveal a significant degree of uncertainty regarding their periods of occupation (Supplementary Figure 3). The calibrated date ranges often span several millennia, even though it is more plausible that each site was occupied for a considerably shorter—albeit still extended—period (Chabai et al., 2020; Nuzhnyi, 2015; Zaliznyak, 1998). When examining the relative sequence of site occupations, the medians of the KDE plots suggest the following chronological order: Barmaky first, followed by Mizyn, Mezhyrich, Ieliseevichi, and Dobranychivka. This inferred sequence can be corroborated through the application of the *Order* function in OxCal (Supplementary Table 1). Then, Mizyn started definitely earlier than Mezhyrich (probability -0.95), while three widely spaced dates of Dobranychivka do not allow for delimiting of the occupation timespan at the latter site.

Probability $t_1 < t_2$			
t_1	t_2		
	Start Mezhyrich	Start Mizyn	Start Dobranychivka
Start Mezhyrich	0	0.04689	0.479
Start Mizyn	0.9531	0	0.6276
Start Dobranychivka	0.521	0.3724	0

Supplementary Table 1. Ordering of three figurine-yielding sites of Central Eastern European Epigravettian. Done in OxCal 4.4.4 (Bronk Ramsey 2023) with IntCal20 calibration curve (Reimer et al. 2020)

When modeled as independent phases—meaning each site is treated as a separate, non-constrained phase—the resulting chronologies are largely synchronous (Table 2). The breadth of the chronological intervals is primarily determined by the quality of the available radiocarbon dates: the intervals are narrowest for sites dated predominantly by AMS, which typically yields smaller standard deviations (e.g., Mezhyrich), and widest for sites dated mainly using conventional radiocarbon methods, which tend to produce larger standard deviations (e.g., Ieliseevichi).

Site	Modelled date calBP	Uncertainty
Barmaky	20871-15783	98.4
Ieliseevichi	20678-15559	99.4
Mezhyrich	18514-17464	99.9
Mizyn	19658-16861	99.7
Dobranychivka	20614-11786	99.3

Supplementary Table 2. Chronological estimates for the occupation span of selected Epigravettian sites of the Central East European Plain. Done in OxCal 4.4.4 (Bronk Ramsey 2023) with IntCal20 calibration curve (Reimer et al. 2020)

An alternative strategy may be considered. By accepting the sequential development of the sites, we can selectively disregard certain legacy dates—as well as some AMS dates—that poorly fit the hypothesis of a chronological sequence. Specifically, dates obtained from

mammoth bones (due to the potential “mammoth-gathering” effect) and those from questionable stratigraphic contexts can be excluded. This approach opens the possibility for a clearer chronological separation between the sites (OxCal Sequential Phases Model 2: Mizyn – 18,466–18,217 modelled calBP, 2 σ ; Mezhyrich – 18,245–17,455 calBP, 2 σ ; Dobranychivka – 17,706–14,464 modelled calBP, 2 σ ; see Supplementary Materials 3).

However, these Bayesian estimates are largely influenced by the initial selection of radiocarbon dates, and the resulting chronological ranges should be treated with caution. They require further verification through improved stratigraphic control and additional radiocarbon dating. At present, the available radiocarbon evidence suggests a largely synchronous occupation of all three sites. It is more plausible that, although the sites may have initially emerged in the order indicated by the earlier dates, their use overlapped over extended and potentially interspersed periods.

Thus, there is no radiocarbon evidence to support the idea that certain forms of portable art in the Epigravettian of the Central East European Plain represent the starting point of a typological progression, an artistic refinement in image representation, or any other sequential development in symbolism or morphology.

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OxCal model for the data from Supplementary 2

Model 1. Overlapping phases

```
Plot()
{
  Outlier_Model("General",T(5),U(0,4),"t");
  Phase()
  {
    Sequence()
    {
      Boundary("Start Dobranychivka");
      Phase("Dobranychivka")
      {
        R_Date("OxA-778",12700,200)
        {
          Outlier("General", 0.05);
        };
        R_Date("OxA-12108",13900,90)
        {
          Outlier("General", 0.05);
        };
        R_Date("GrA-22472",14350,90)
        {
          Outlier("General", 0.05);
        };
        Date("DateDobranychivka")
        {
          color="blue";
        };
      };
      Boundary("End Dobranychivka");
    };
    Sequence()
    {
      Boundary("Start Mezhyrich");
      Phase("Mezhyrich")
      {
        R_Date("SacA-14986",15430,90)
```

```
{
  Outlier("General", 0.05);
};
R_Date("SacA-12040",15320,90)
{
  Outlier("General", 0.05);
};
R_Date("QC-900",15245,1080)
{
  Outlier("General", 0.05);
};
R_Date("SacA-14981",15210,130)
{
  Outlier("General", 0.05);
};
R_Date("SacA-11176",15030,90)
{
  Outlier("General", 0.05);
};
R_Date("SacA-12259",14970,90)
{
  Outlier("General", 0.05);
};
R_Date("SacA-14984",14920,90)
{
  Outlier("General", 0.05);
};
R_Date("SacA-12041",14830,90)
{
  Outlier("General", 0.05);
};
R_Date("SacA-11177d",14810,90)
{
  Outlier("General", 0.05);
};
R_Date("OxA-15587",14790,60)
{
  Outlier("General", 0.05);
};
R_Date("GrN-38810c",14750,50)
{
  Outlier("General", 0.05);
};
R_Date("GIN-2593",14700,500)
{
  Outlier("General", 0.05);
};
R_Date("SacA-11486",14610,60)
{
  Outlier("General", 0.05);
};
R_Date("SacA-11487",14600,60)
```

```

{
  Outlier("General", 0.05);
};
R_Date("GrN-22094b",14600,110)
{
  Outlier("General", 0.05);
};
R_Date("GrA-38787",14590,60)
{
  Outlier("General", 0.05);
};
R_Date("GrN-29877",14560,70)
{
  Outlier("General", 0.05);
};
R_Date("GrN-29876",14550,70)
{
  Outlier("General", 0.05);
};
R_Date("GIN-2595",14530,300)
{
  Outlier("General", 0.05);
};
R_Date("GrA-22501",14450,90)
{
  Outlier("General", 0.05);
};
R_Date("AA-1317",14420,190)
{
  Outlier("General", 0.05);
};
R_Date("OxA-712",14400,250)
{
  Outlier("General", 0.05);
};
R_Date("SacA-14982",14400,90)
{
  Outlier("General", 0.05);
};
R_Date("OxA-13044a",14380,60)
{
  Outlier("General", 0.05);
};
R_Date("QC-897",14320,270)
{
  Outlier("General", 0.05);
};
R_Date("GIN-2596",14300,300)
{
  Outlier("General", 0.05);
};
Date("DateMezhyrich")

```

```

{
  color="blue";
};
};
Boundary("End Mezhyrich");
};
Sequence()
{
  Boundary("Start Mizyn");
  Phase("Mizyn")
  {
    R_Date("OxA--13825",14450,70)
    {
      Outlier("General", 0.05);
    };
    R_Date("GrA--22499",14560,90)
    {
      Outlier("General", 0.05);
    };
    R_Date("OxA-719",15100,200)
    {
      Outlier("General", 0.05);
    };
    R_Date("SPb--662",15340,300)
    {
      Outlier("General", 0.05);
    };
    R_Date("Ki--11084",15600,250)
    {
      Outlier("General", 0.05);
    };
    Date("DateMizyn")
    {
      color="blue";
    };
  };
  Boundary("End Mizyn");
};
Order("Art")
{
  Date("=Start Mezhyrich");
  Date("=Start Mizyn");
  Date("=Start Dobranychivka");
};
};

```

Model 2. Contiguous phases

```

Plot()
{
  Sequence()
  {
    Boundary("Start Mizyn");

```

```

Phase("Mizyn")
{
  R_Date("OxA-13825",14450,70);
  R_Date("GrA-22499",14560,90);
  R_Date("OxA-719",15100,200);
  R_Date("SPb-662",15340,300);
  R_Date("Ki-11084",15600,250);
};
Boundary("Transition 1/2");
Phase("Mezhyrich")
{
  R_Date("SacA-14986",15430,90);
  R_Date("SacA-12040",15320,90);
  R_Date("QC-900",15245,1080);
  R_Date("SacA-14981",15210,130);
  R_Date("SacA-11176",15030,90);
  R_Date("SacA-12259",14970,90);
  R_Date("SacA-14984",14920,90);
  R_Date("SacA-12041",14830,90);
  R_Date("SacA-11177d",14810,90);
  R_Date("OxA-15587",14790,60);
  R_Date("GrN-38810c",14750,50);
  R_Date("GIN-2593",14700,500);
  R_Date("SacA-11486",14610,60);
  R_Date("SacA-11487",14600,60);
  R_Date("GrN-22094b",14600,110);
  R_Date("GrA-38787",14590,60);
  R_Date("GrN-29877",14560,70);
  R_Date("GrN-29876",14550,70);
  R_Date("GIN-2595",14530,300);
  R_Date("GrA-22501",14450,90);
  R_Date("AA-1317",14420,190);
  R_Date("OxA-712",14400,250);
  R_Date("SacA-14982",14400,90);
  R_Date("OxA-13044a",14380,60);
  R_Date("QC-897",14320,270);
  R_Date("GIN-2596",14300,300);
};
Boundary("Transition 2/3");
Phase("Dobranshchivka")
{
  R_Date("OxA-778",12700,200);
  R_Date("OxA-12108",13900,90);
  R_Date("GrA-22472",14350,90);
};
Boundary("End Dobranshchivka");
};

```

Supplementary 3

**Images of artifacts under study and their research and digitization
context**

In total, 18 anthropomorphic mammoth ivory figurines were discovered at Mizyn (Radievska 2008). Eleven of them were found by Khvedir Vovk during the campaign of 1908–1909 and associated with the complex No. 1 — the accumulation of mammoth bones (Sergin 1987). Specific information regarding the archaeological context of these items is lacking. The other seven were found during 1912–1913 by Levko Chykalenko and were mainly associated with complex No. 2, which was later interpreted as a dwelling made of mammoth bones and ivory. Three of them, found in connection with other assemblage pieces, were situated in the southern part of complex No. 2, and likely placed under the mammoth skull (Chykalenko 1912; Sergin 1987: 66).

Differences in the shapes of figurines associated with Complex 1 and Complex 2 were identified early on and expressed in the conventional stylistic typologies often attributed to figurines: “phalluses” and “birds” (Volkov 1913; Radievska 2008: 39). However, all rapidly became subsumed under the broad category of “female figurines” (Breuil 1913: 185–188). This interpretation stems from the shape of figurines representing female bodies, with the geometric ornamentation on the “front” displaying highly stylized anthropomorphs. This consensus is dominant today (Efimenko 1953; Abramova 1962; Shovkoplyas 1965; Soffer, Avodasio, & Hyland 2000; Iakovleva 1995; 2009), even though when distinguishing their shape, scholars still refer to conventional definitions (Shovkoplyas 1965; Yakovleva 2011), or develop on them, nuancing their interpretations as phalluses, birds, female figurines, or a superposition of these three (Salmony 1949; Boriskovskiy 1953; Stolyar 1972; Jöris 2021). A more focused look at ornaments suggested interpreting them as clothes (Salmony 1949; Filippov 1983), tattooing (Burkitt 1925), or a replication of natural ornamentation (Bibikova 1965; Marshack 1979). Abstracting from interpretational details, they were recently reclassified in four types by their shape, essentially nuancing Vovk’s classification

(Iakovleva 2011): “schematized phalluses” (No. F1—3), “schematized female figurines” (No. F4—10), “schematized female figurines similar to birds” (No. F11—17), and a figure that looks like a part of the female body (No. F18).

The mammoth tusk is composed of concentric dentin growth layers intersected by radial microchannels. This structure allows easy penetration of moisture, microorganisms, and chemical compounds and determines how the products are destroyed after burial. However, most of the observed damage on the figurines appears to result not from external mechanical forces but from internal processes, namely, the slow dehydration of dentin layers, leading to controlled cracking along pre-existing structural weaknesses. Thus, the external parts detached first, revealing the core of the artifact. Typically, this was predated with two longitudinal cracks on the back side of the figurine that collided in the upper section of the figurine, causing the breakage of its tip. Simultaneously, the wider middle section of the figurines broke off into several smaller pieces, exposing their internal parts for further weathering. Such a destruction pattern is notable as it follows the structure of raw material, which allows for reassembling the item from many pieces by finding the neighboring ivory pieces. The sequence differs for “bird-like” figurines F11–18, where the narrow and thin “tale” broke off first. Out of these eight, only one piece has its upper section intact, and three more were reassembled. Four “tales” were never discovered.

Originally kept by Khvedir Vovk, the first researcher of the Mizyn site, the figurines were stored in Saint Petersburg. In the early 1920s, figurines were transferred to Kyiv, where they became part of the Cabinet of Anthropology and Ethnology at the All-Ukrainian Academy of Sciences. Following a series of institutional reorganizations driven by ideological shifts in the USSR, the Mizyn materials were moved in 1936 to the Central Historical Museum, now known as the National Museum of the History of Ukraine (Radievska 2008). During World War

II, the figurines were evacuated to Ufa (in present-day Russia) and returned to Kyiv in the late 1940s (Radiievska 2008).

This complex history of relocation had adverse effects on the preservation of the fragile ivory artifacts, which underwent at least three documented conservation interventions. The first ones occurred shortly after the figurines' discovery and involved the reassembly of delaminated fragments, followed by surface treatments with wax and varnish. In 1959, a second phase of restoration was carried out at the Hermitage Restoration Center in Saint Petersburg, which included additional gluing and impregnation with a stabilizing solution. The most recent documented restoration, conducted in 1990 at the All-Union Scientific Research Institute for Restoration (Moscow, Russian Federation), involved surface cleaning with ethyl alcohol to remove sediment residues, dark stains, and the earlier wax coating. The artifacts were also impregnated with a 1.25% acrylic copolymer solution (BMK-5) to strengthen their structure. Delaminated parts were rejoined using a 5% polyvinyl butyral-based adhesive, and missing areas were filled with tinted gypsum.

Given their uniqueness, the objects are stored under strictly controlled temperature and humidity conditions, in the absence of light, and placed on custom-made supports composed of soft, inert materials that conform to the shape of each artifact and prevent localized pressure. As pieces are highly fragile, no high-quality digital documentation was performed, as even non-invasive photogrammetric procedures are considered too intrusive for some of these artefacts. In 2023, six were selected for the image-based 3D modeling and digital preservation in course of the “Preserving Ukrainian Legacy” project, held by NGO “Archaic” in partnership with the National Museum of the History of Ukraine and NCO “CyArk”; others were photographed and analyzed visually to the extent their condition allows. The use of these novel documentation techniques and the war-caused accessibility of figurines

allowed for a new look at the production technology and the history of artmaking of these unique pieces.

Supplementary Table 3. Summarized reference details on Mizyn figurines

No in the text	3D modeling ID	Conventional shape identification (after Volkov 1913; Yakovleva 2009)	Type identification by Yakovleva (2011)	Ornamented (Y/N)
1	NMIU52	Phallic	1	+
2	NMIU57	Phallic	1	+
3	—	Phallic	1	+
4	NMIU53	Phallic	2	+
5	NMIU55	Phallic	2	+
6	—	Phallic	2	+
7	—	Phallic	2	+
8	NMIU59	Phallic	2	+
9	—	Phallic	2	—
10	—	Phallic	2	—
11	—	Bird-like	3	—
12	—	Bird-like	3	+
13	—	Bird-like	3	+
14	—	Bird-like	3	+
15	—	Bird-like	3	+
16	—	Bird-like	3	+
17	—	Bird-like	3	+
18	NMIU56	Zoomorphic	4	—

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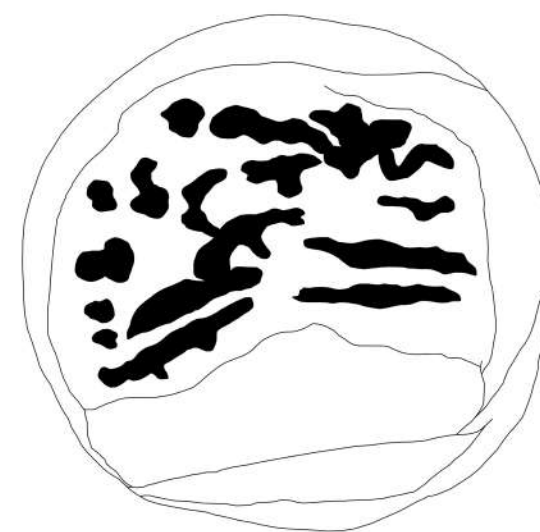
Volkov, Th. 1913. Nouvelles découvertes dans la station paléolithique de Mézine, Ukraine. In *Compte rendu de la XIVe session du Congrès international d'anthropologie et d'archéologie préhistoriques, Genève 1912. Volume 1*. Genève: Albert Kundig, 415.

No. 1 – NMIU52



0 2 cm

No. 1 – NMIU52



0 1 cm

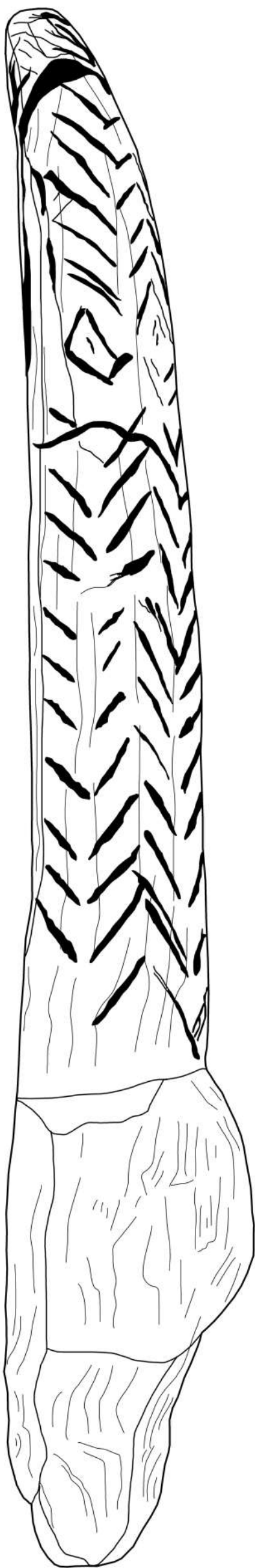
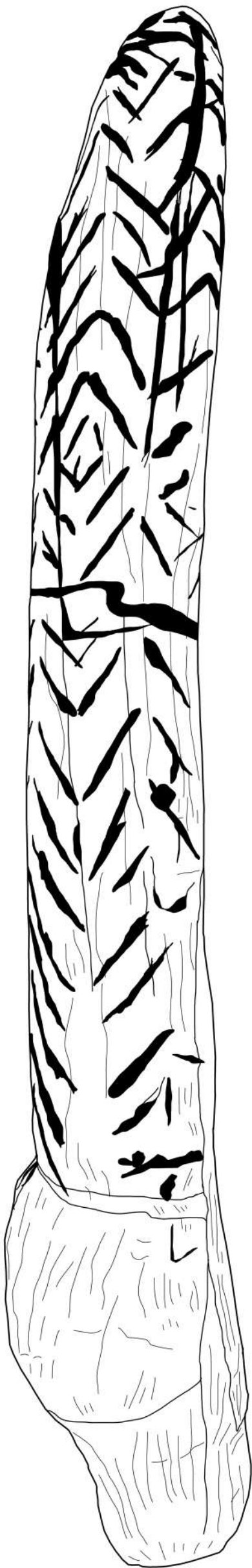
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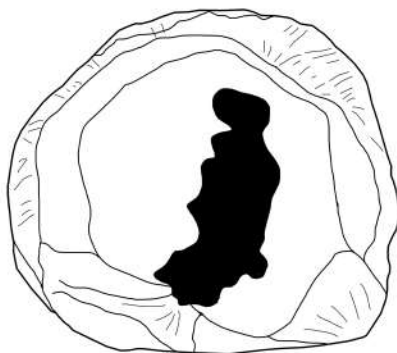
0 2 cm



No. 2 – NMIU57



0 1 cm

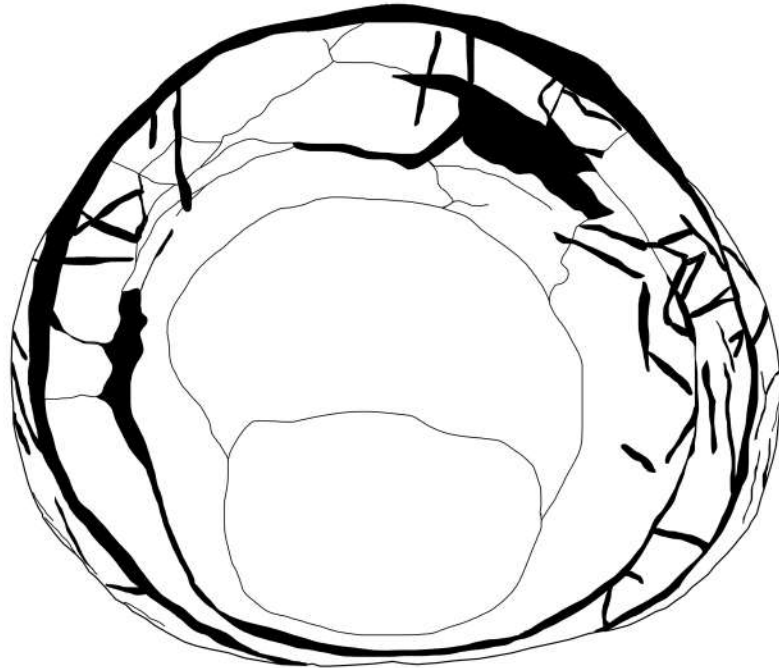
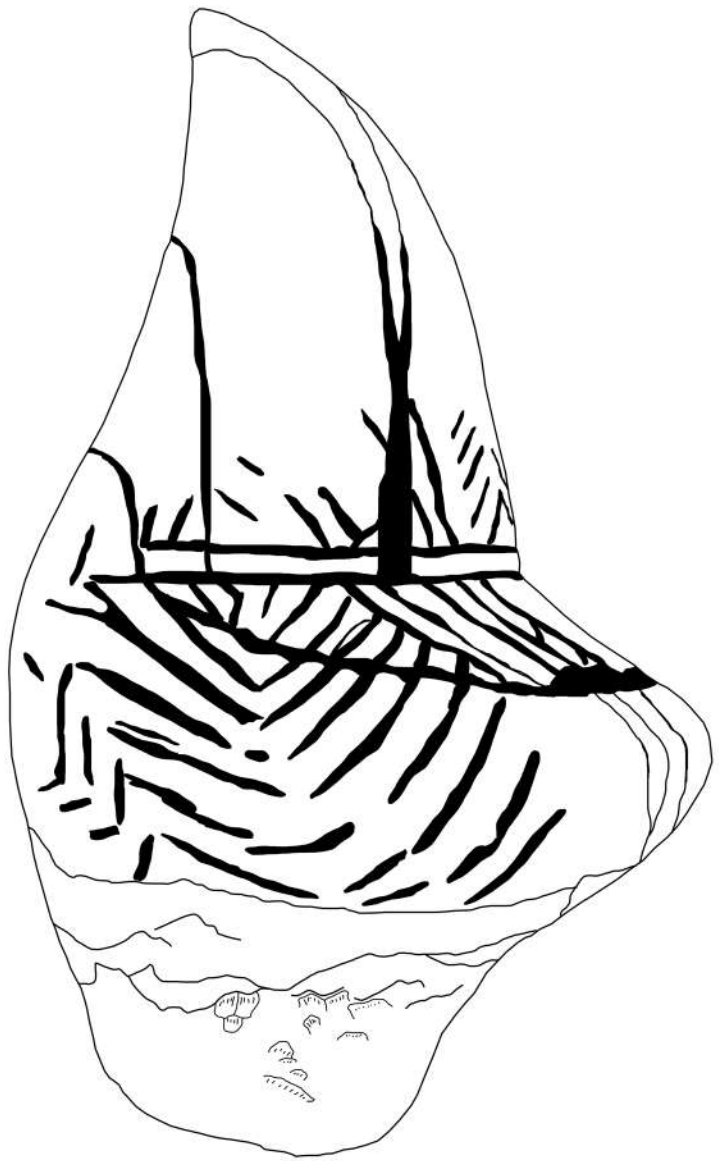
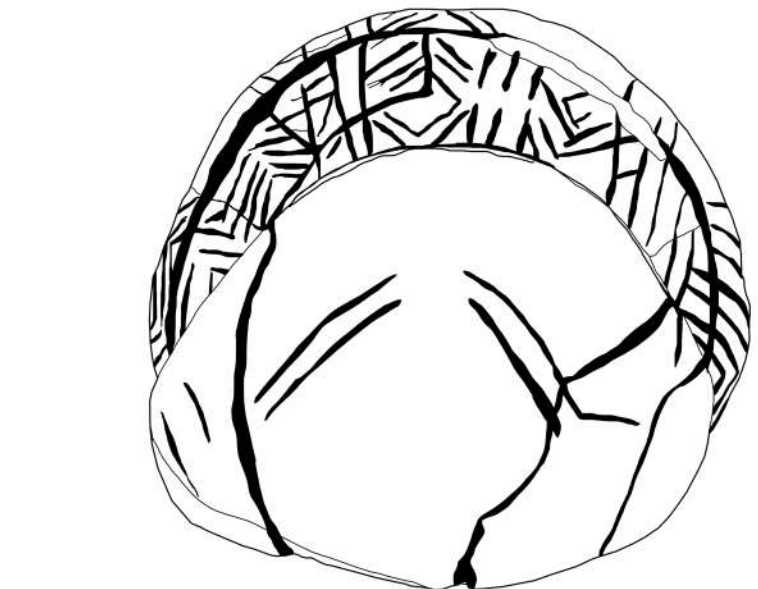


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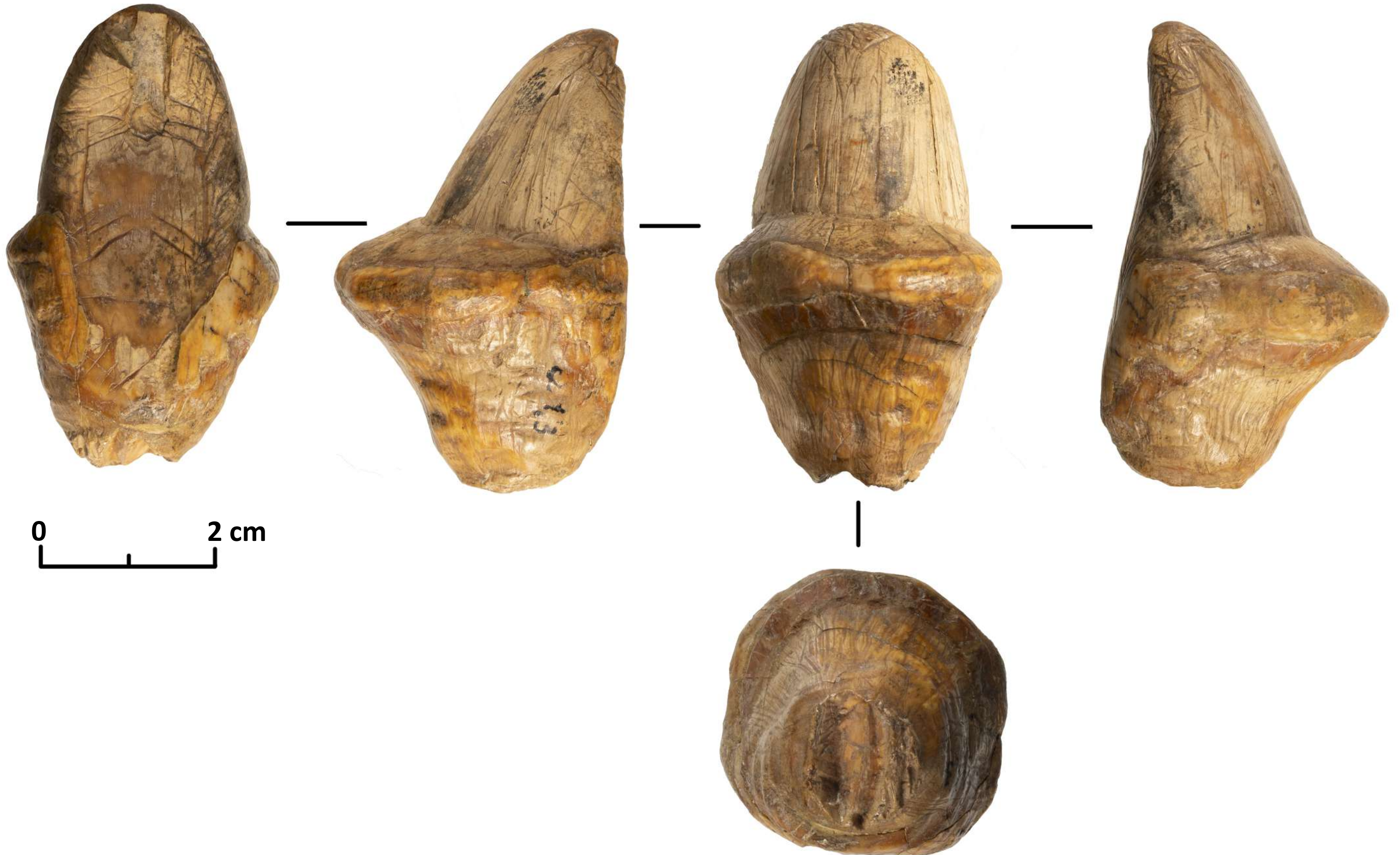
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No. 4 – NMIU53



0 1 cm

No. 5 – NMIU55



No. 5 – NMIU55



0 1 cm



No. 6



0 2 cm



No. 7





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No. 8 – NMIU59



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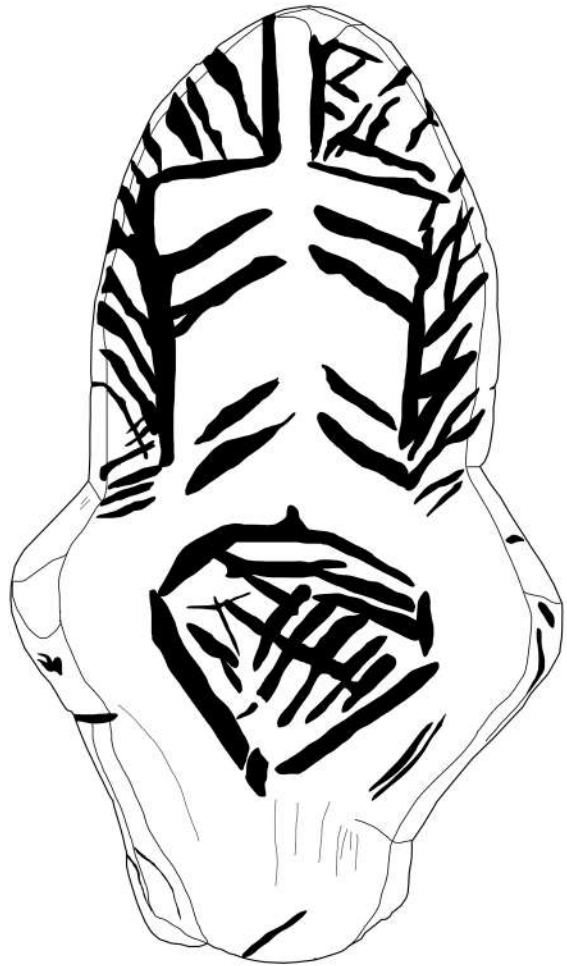
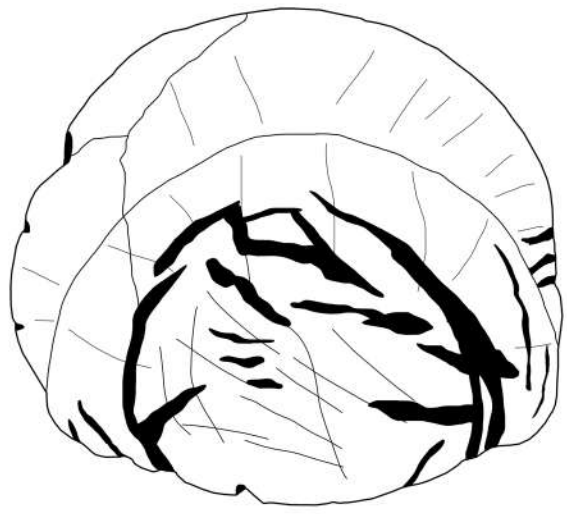


0 2 cm

|



No. 8 – NMIU59



0 1 cm



No. 9



0

2 cm





No. 10



0

2 cm

No. 11



0 2 cm

No. 12



0 2 cm

No. 13



0 2 cm

No. 14



0 2 cm

No. 15



0 2 cm

No. 16



0 2 cm

No. 17



0 2 cm



No. 18 – NMIU56



0 2 cm

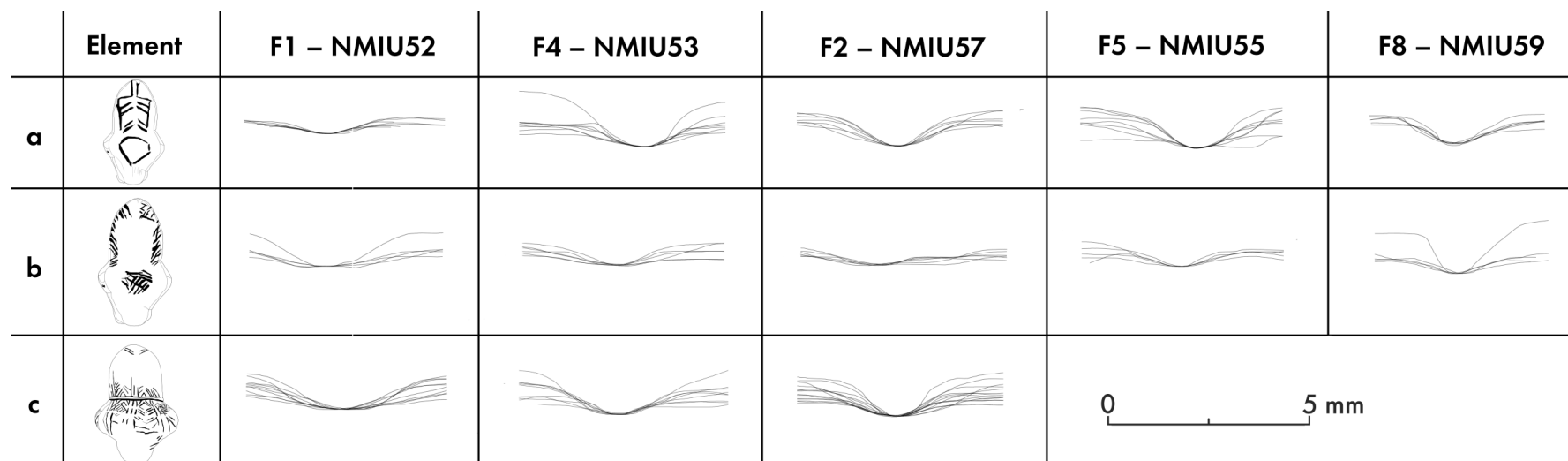
No. 18 – NMIU56



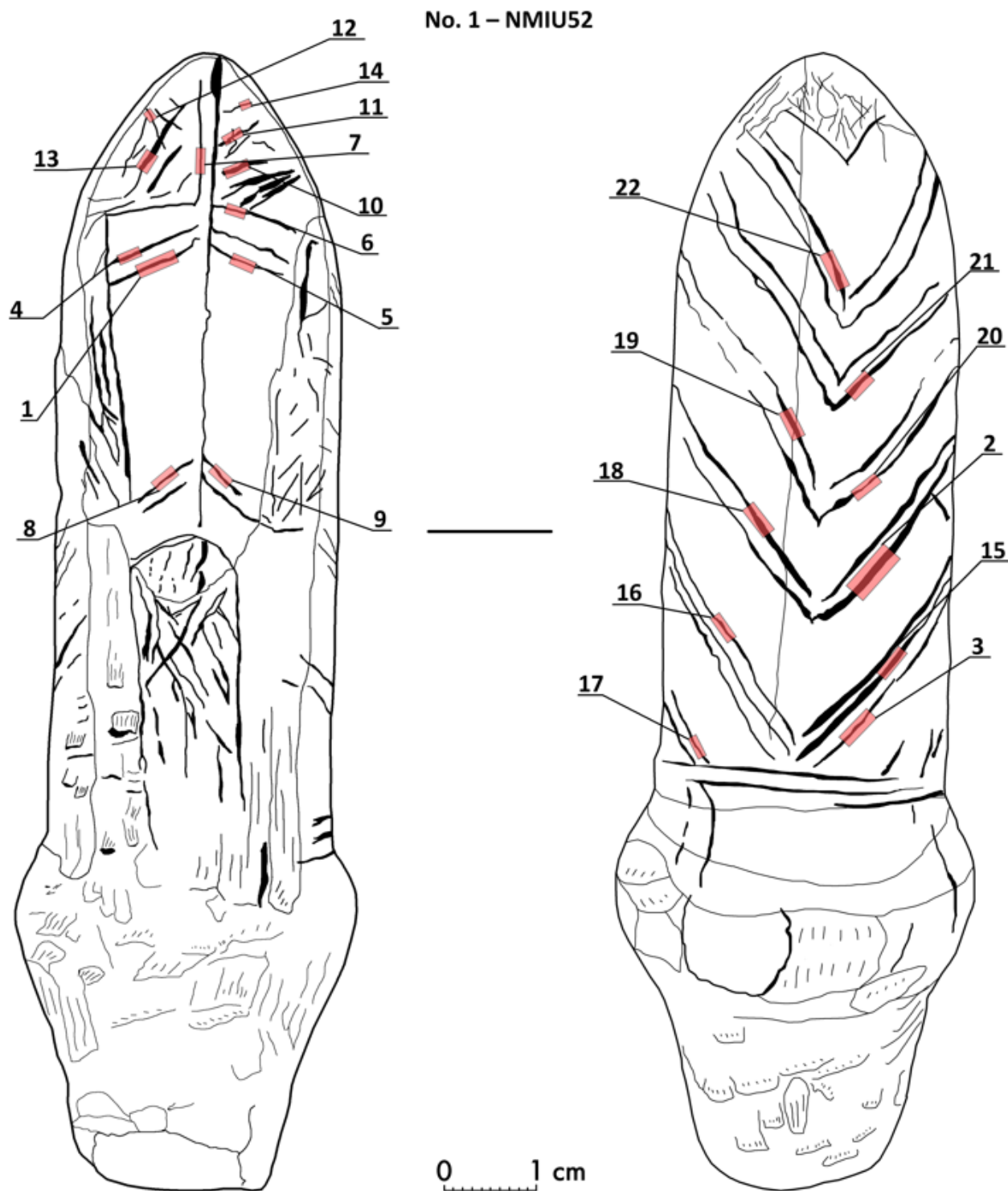
0 1 cm

Supplementary 4

Digital quantitative analysis of the engravings' cross-sections

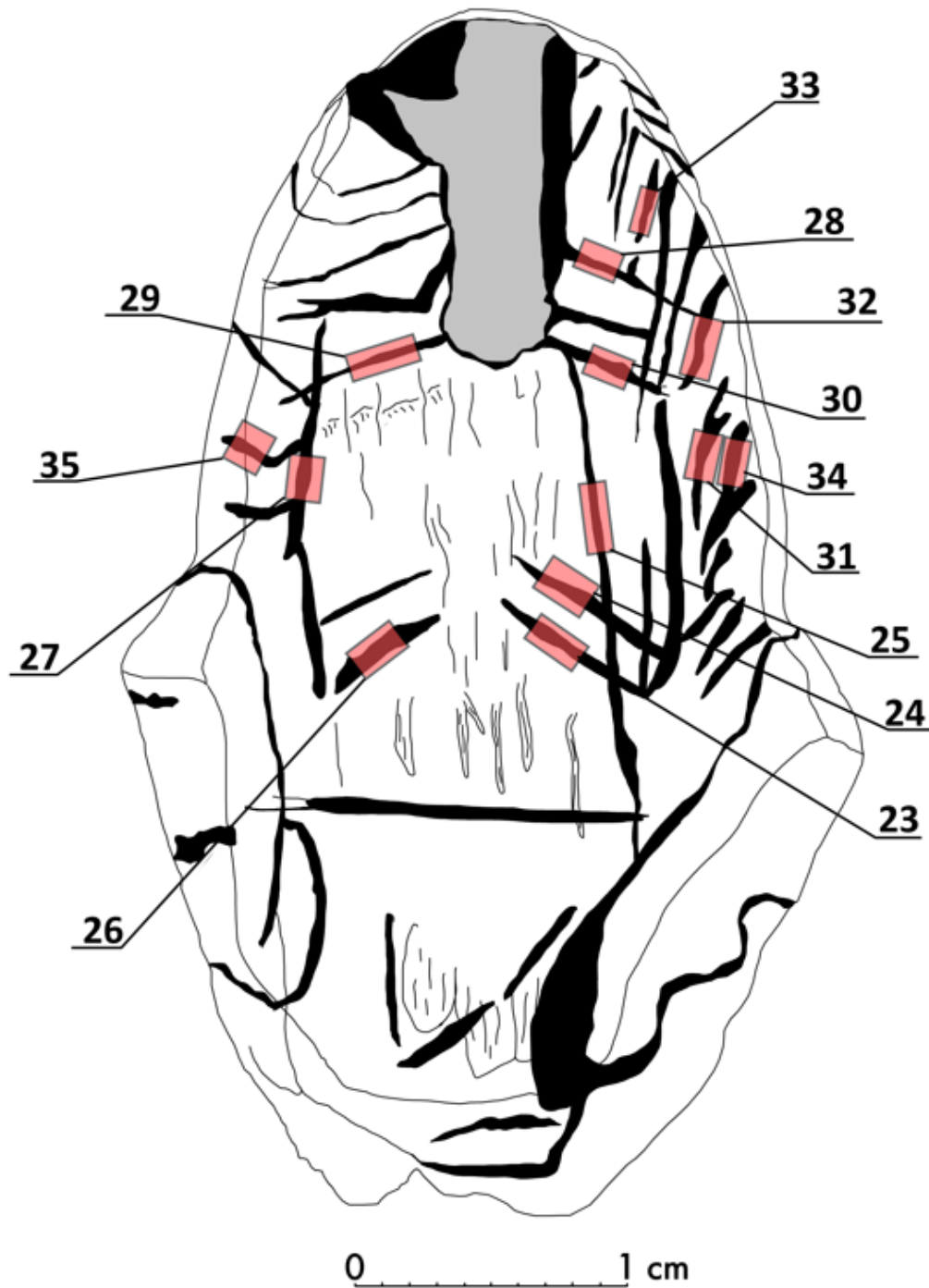


Supplementary Figure 4. Engravings on Mizyn figurines. Superimposition of engravings' cross-sections on different ornamentation zones of Mizyn figurines. a – engravings that mark a figurative motif; b – irregular engravings interpreted as hair or clothing; c – geometric ornamentation

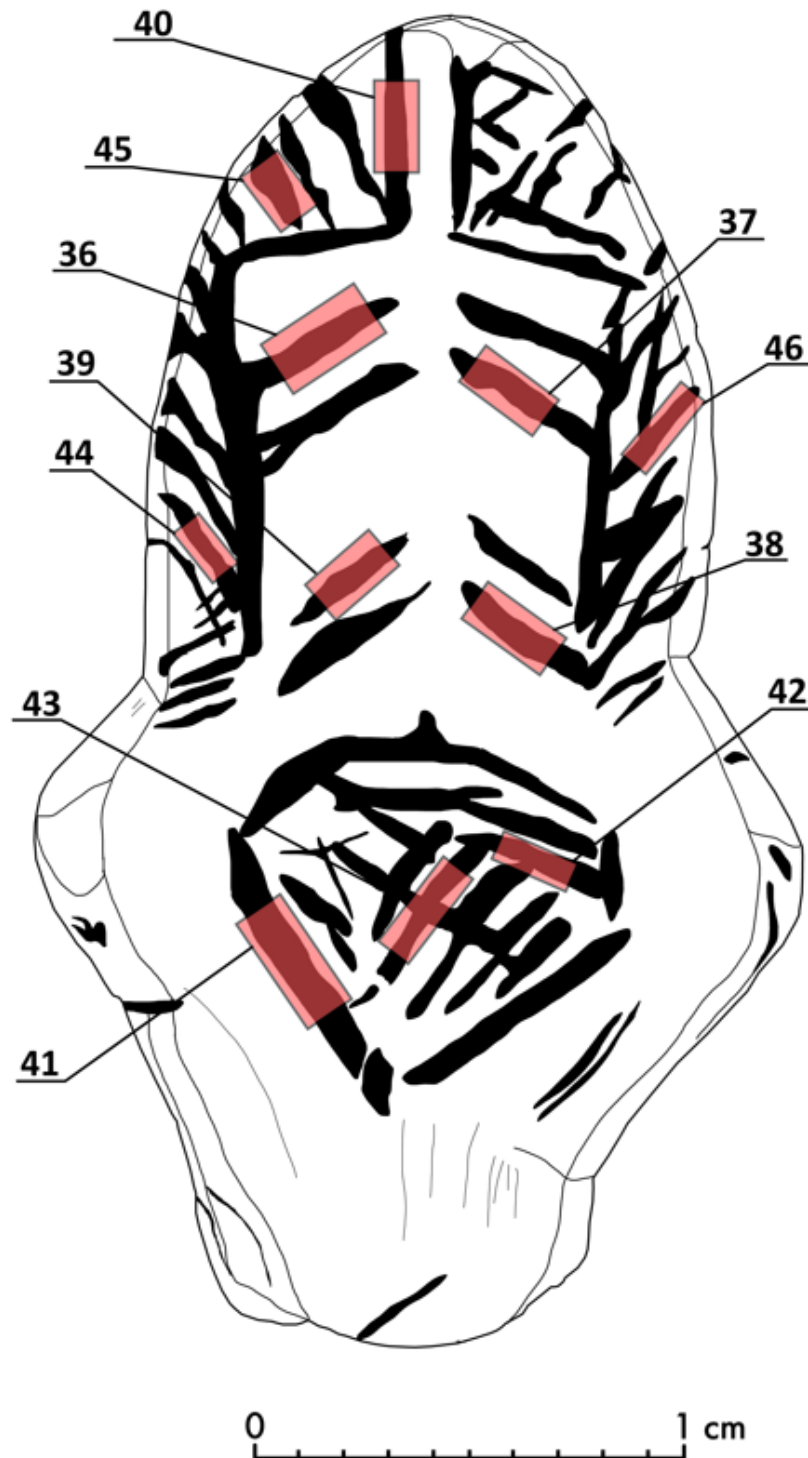


Supplementary Figure 5. Location of analyzed fragments of the figurine F1. Red rectangles mark the exact location of the 3D sample for the cross-section analysis. The sample number corresponds to that in Supplementary Table 4.1.

No. 5 – NMIU55

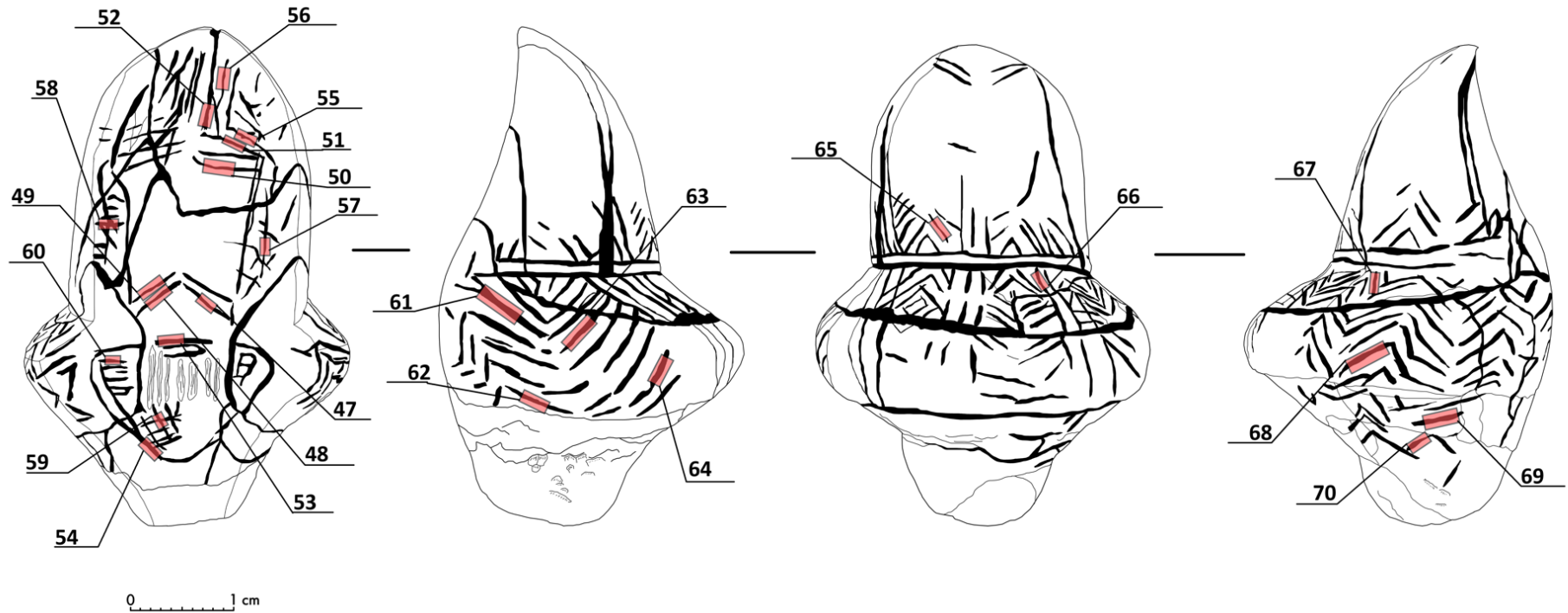


Supplementary Figure 6. Location of analyzed fragments of the figurine F5Red rectangles mark the exact location of the 3D sample for the cross-section analysis. The sample number corresponds to that in Supplementary Table 4.1.



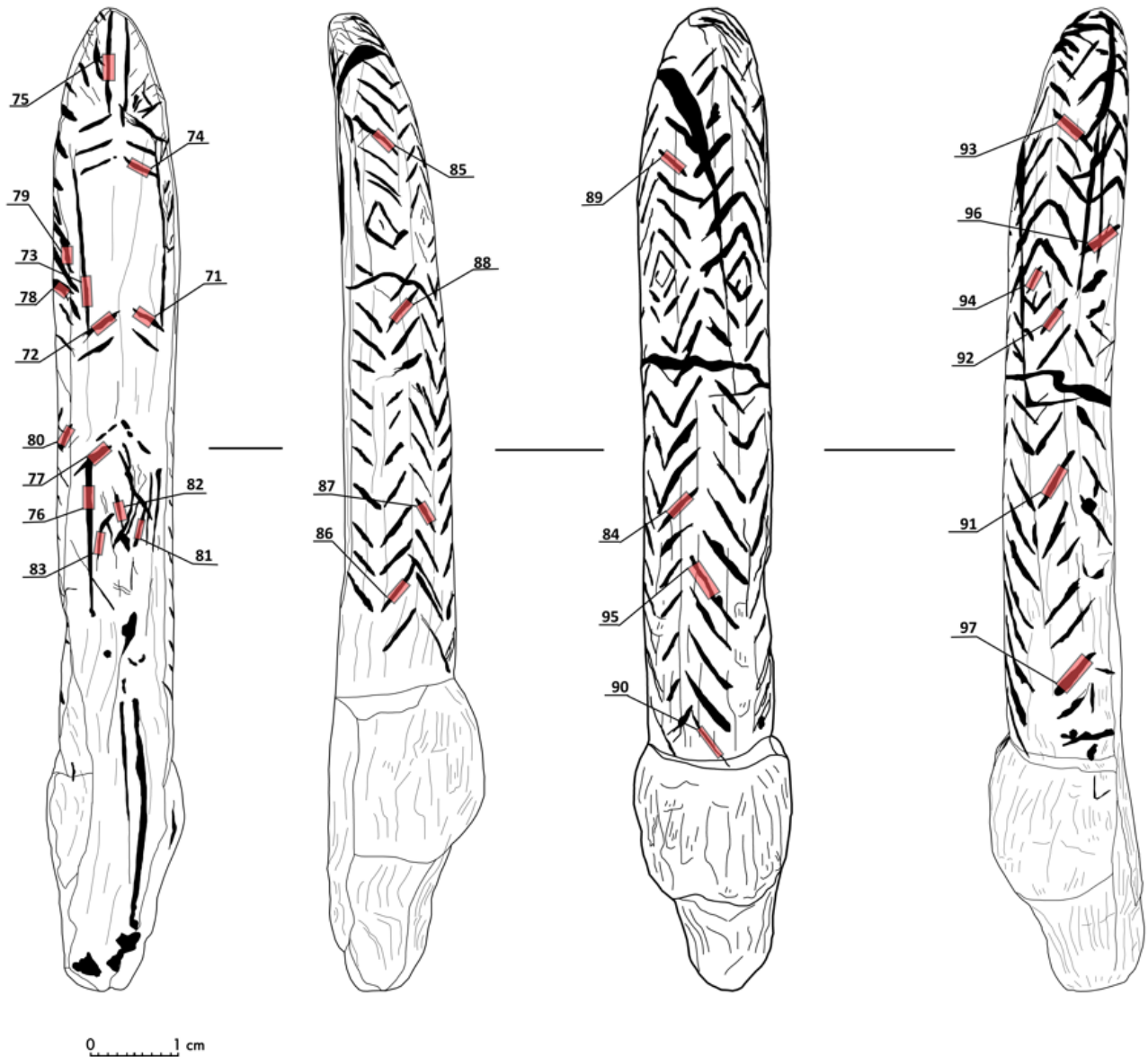
Supplementary Figure 7. Location of analyzed fragments of the figurine F8. Red rectangles mark the exact location of the 3D sample for the cross-section analysis. The sample number corresponds to that in Supplementary Table 4.1.

No. 4 – NMIU53



Supplementary Figure 8. Location of analyzed fragments of the figurine F4. Red rectangles mark the exact location of the 3D sample for the cross-section analysis. The sample number corresponds to that in Supplementary Table 4.1.

No. 2 – NMIU57



Supplementary Figure 9. Location of analyzed fragments of the figurine F2. Red rectangles mark the exact location of the 3D sample for the cross-section analysis. The sample number corresponds to that in Supplementary Table 4.1.

Supplementary Table 4. Quantitative study of engravings' cross sections. Red strings mark engravings that form an image of an anthropomorph; Blue strings mark engravings typically interpreted as hair or clothing; yellow lines mark engraved geometrics

Item	Line	Aperture	Depth	FWMH	Depth/FWMH	Ornamentation group
NMIU52	1	162	0,029	0,234	0,122	Figurative
NMIU52	2	129	0,159	0,520	0,305	Geometric
NMIU52	3	146	0,125	0,543	0,229	Geometric
NMIU52	4	152	0,050	0,274	0,182	Figurative
NMIU52	5	160	0,038	0,255	0,151	Figurative
NMIU52	6	161	0,042	0,342	0,124	Figurative
NMIU52	7	156	0,066	0,405	0,162	Figurative
NMIU52	8	159	0,049	0,324	0,150	Figurative
NMIU52	9	163	0,047	0,385	0,123	Figurative
NMIU52	10	133	0,190	0,558	0,341	Irregular
NMIU52	11	162	0,095	0,748	0,127	Irregular
NMIU52	12	160	0,052	0,456	0,114	Irregular
NMIU52	13	162	0,066	0,710	0,093	Irregular
NMIU52	14	159	0,090	0,610	0,148	Irregular
NMIU52	15	168	0,044	0,569	0,078	Geometric
NMIU52	16	157	0,084	0,595	0,141	Geometric
NMIU52	17	160	0,078	0,576	0,135	Geometric
NMIU52	18	161	0,077	0,647	0,119	Geometric
NMIU52	19	130	0,195	0,543	0,359	Geometric
NMIU52	20	147	0,114	0,529	0,216	Geometric
NMIU52	21	141	0,132	0,514	0,258	Geometric
NMIU52	22	127	0,161	0,492	0,328	Geometric
NMIU55	23	114	0,206	0,403	0,512	Figurative
NMIU55	24	144	0,113	0,554	0,203	Figurative
NMIU55	25	122	0,200	0,458	0,436	Figurative
NMIU55	26	122	0,198	0,505	0,391	Figurative
NMIU55	27	136	0,146	0,518	0,281	Figurative
NMIU55	28	136	0,112	0,373	0,299	Figurative
NMIU55	29	156	0,043	0,273	0,156	Figurative
NMIU55	30	145	0,156	0,668	0,233	Figurative
NMIU55	31	157	0,048	0,294	0,162	Irregular
NMIU55	32	144	0,074	0,286	0,260	Irregular
NMIU55	33	156	0,050	0,325	0,153	Irregular

NMIU55	34	156	0,046	0,345	0,134	Irregular
NMIU55	35	150	0,079	0,375	0,209	Irregular
NMIU59	36	139	0,145	0,459	0,316	Figurative
NMIU59	37	133	0,160	0,473	0,337	Figurative
NMIU59	38	137	0,128	0,384	0,334	Figurative
NMIU59	39	144	0,114	0,413	0,276	Figurative
NMIU59	40	112	0,195	0,328	0,594	Figurative
NMIU59	41	123	0,162	0,383	0,423	Figurative
NMIU59	42	150	0,075	0,366	0,205	Irregular
NMIU59	43	161	0,061	0,416	0,145	Irregular
NMIU59	44	136	0,079	0,252	0,315	Irregular
NMIU59	45	96	0,257	0,389	0,660	Irregular
NMIU59	46	154	0,139	0,366	0,379	Irregular
NMIU53	47	131	0,141	0,388	0,363	Figurative
NMIU53	48	129	0,113	0,371	0,305	Figurative
NMIU53	49	134	0,112	0,372	0,301	Figurative
NMIU53	50	148	0,077	0,350	0,219	Figurative
NMIU53	51	130	0,108	0,337	0,321	Figurative
NMIU53	52	101	0,260	0,398	0,652	Figurative
NMIU53	53	131	0,119	0,329	0,362	Figurative
NMIU53	54	150	0,089	0,419	0,213	Figurative
NMIU53	55	151	0,075	0,405	0,186	Irregular
NMIU53	56	153	0,065	0,323	0,202	Irregular
NMIU53	57	147	0,103	0,509	0,203	Irregular
NMIU53	58	168	0,061	0,521	0,117	Irregular
NMIU53	59	160	0,066	0,556	0,120	Irregular
NMIU53	60	164	0,034	0,325	0,103	Irregular
NMIU53	61	132	0,156	0,459	0,339	Geometric
NMIU53	62	119	0,167	0,420	0,398	Geometric
NMIU53	63	141	0,131	0,441	0,298	Geometric
NMIU53	64	141	0,125	0,431	0,290	Geometric
NMIU53	65	146	0,053	0,221	0,241	Geometric
NMIU53	66	148	0,099	0,428	0,232	Geometric
NMIU53	67	139	0,079	0,253	0,313	Geometric
NMIU53	68	144	0,091	0,358	0,253	Geometric
NMIU53	69	125	0,299	0,705	0,424	Geometric
NMIU53	70	133	0,175	0,507	0,345	Geometric
NMIU57	71	126	0,180	0,437	0,410	Figurative
NMIU57	72	142	0,105	0,380	0,276	Figurative
NMIU57	73	118	0,143	0,323	0,442	Figurative

NMIU57	74	118	0,155	0,326	0,475	Figurative
NMIU57	75	140	0,095	0,380	0,250	Figurative
NMIU57	76	115	0,138	0,270	0,510	Figurative
NMIU57	77	144	0,093	0,340	0,272	Figurative
NMIU57	78	153	0,104	0,622	0,167	Irregular
NMIU57	79	150	0,083	0,382	0,216	Irregular
NMIU57	80	166	0,051	0,743	0,068	Irregular
NMIU57	81	153	0,065	0,341	0,190	Irregular
NMIU57	82	169	0,031	0,379	0,081	Irregular
NMIU57	83	159	0,042	0,264	0,159	Irregular
NMIU57	84	152	0,065	0,263	0,247	Geometric
NMIU57	85	143	0,072	0,312	0,232	Geometric
NMIU57	86	105	0,159	0,280	0,569	Geometric
NMIU57	87	124	0,131	0,302	0,435	Geometric
NMIU57	88	124	0,133	0,334	0,397	Geometric
NMIU57	89	159	0,055	0,130	0,420	Geometric
NMIU57	90	121	0,117	0,271	0,433	Geometric
NMIU57	91	133	0,097	0,306	0,317	Geometric
NMIU57	92	131	0,100	0,277	0,362	Geometric
NMIU57	93	128	0,123	0,350	0,350	Geometric
NMIU57	94	136	0,076	0,243	0,311	Geometric
NMIU57	95	129	0,122	0,332	0,369	Geometric
NMIU57	96	140	0,129	0,431	0,299	Geometric
NMIU57	97	133	0,178	0,558	0,320	Geometric

Supplementary 5

Parameters of image acquisition and processing for image-based 3D modeling

Supplementary Table 5. Specifications of the photogrammetric equipment

Parameter	Value
Camera model	Sony α7R III / ILCE-7RM3
Sensor type	35mm full frame (35.9×24.0mm), Exmor R CMOS sensor
Effective pixels	42.4 Megapixels
Width, pix	7902
Height, pix	5304
Color depth, bit	24
Image processor	BIONZ X
ISO	100–32000
Shutter	1 / 8000—30 s
Lens model	Sigma F2.8 DG DN MACRO
Focal length	105 mm
Lens Construction	17 Elements in 12 Groups
Maximum Aperture	f / 2.8
Minimum Aperture	f / 22
Focus Modes	Auto focus
Closest focus	29.5 cm

Supplementary Table 6. Parameters of PC used for image processing and 3D modeling procedures

Processor	AMD Ryzen 7 7745HX
Clock rate	3.60 GHz
RAM	32 Gb
Visual processor	NVIDIA® GeForce RTX™ 4070 8GB GDDR6
Operational system	Windows 11, 64bit
Software	Reality Capture v. 1.5

Supplementary Table 7. Image acquisition parameters for 3D modeling

ID	Aperture	Exposure, s	ISO	Focal distance, mm	Number of images
F1	1/16	1–2	125–200	105	297
F2	1/16	1–1.3	100–160	105	173
F4	1/16	1.6–2	125–160	105	335
F5	1/16	1.3–2	125–160	105	267
F8	1/16	2	100	105	190
F18	1/16	1.3	125–160	105	153

Data Capturing Strategy

All six objects were placed on the manual rotary table with the black background. Several loops (rounds of images with different camera-to-object positioning) were acquired. Some loops required an additional holder to fix the artifact. The camera was positioned on a tripod, alongside the two light sources, to minimize dynamic shadows. The camera and one light source were equipped with a dynamic polarizer. The shutter is released remotely by a controller. 5 to 6 scale bars are located around the object.

F1: 292 digital images in 8 horizontal loops. Sharp edges were acquired in an extra loop for additional precision.

F2: 173 images in 4 horizontal and two vertical loops. Sharp edges were acquired in an extra loop for additional precision.

F4: 335 images in 7 horizontal and two vertical loops. Sharp edges were acquired in an extra loop for additional precision.

F5: 267 images in 7 horizontal and two vertical loops. Sharp edges were acquired in an extra loop for additional precision.

F8: 190 images in 5 horizontal and two vertical loops. Sharp edges were acquired in an extra loop for additional precision.

F18: 153 images in 6 horizontal and one vertical loops. Sharp edges were acquired in an extra loop for additional precision.

Supplementary Table 8. Metric parameters of artifacts and 3D models

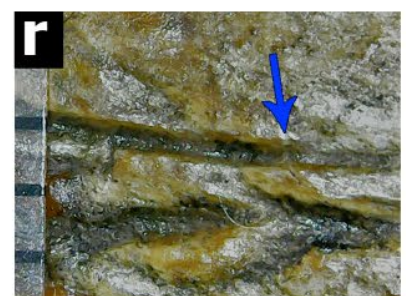
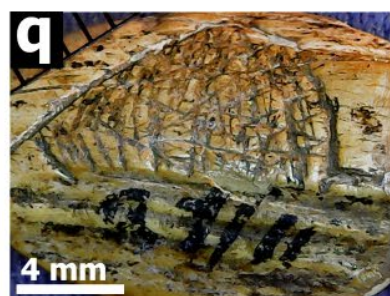
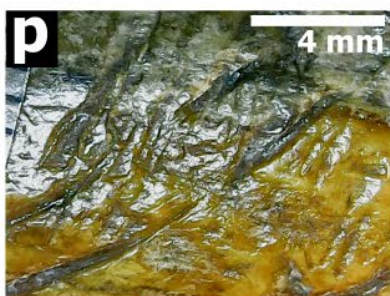
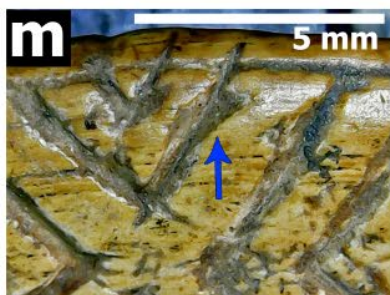
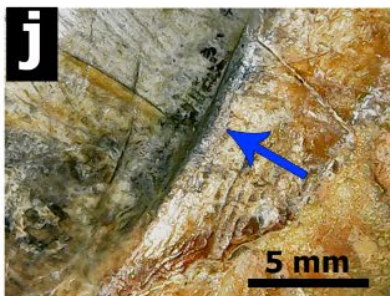
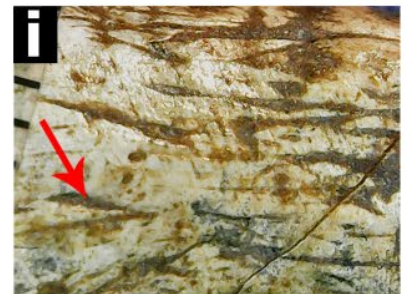
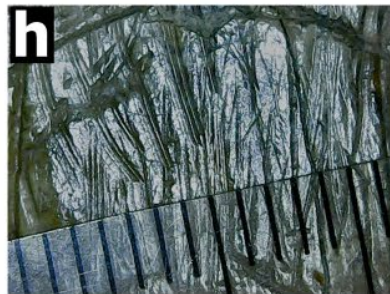
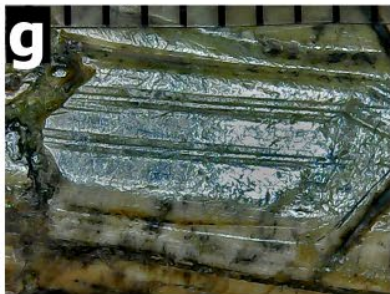
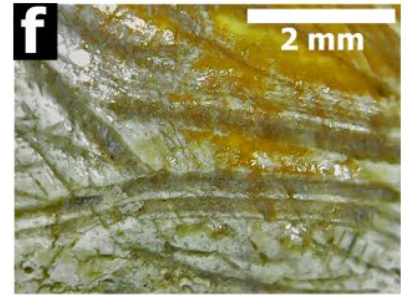
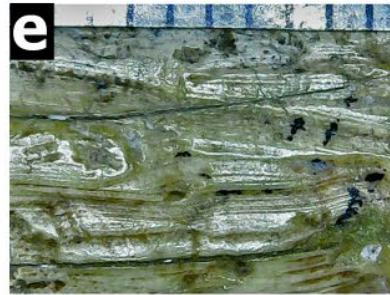
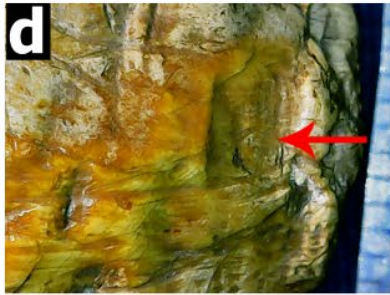
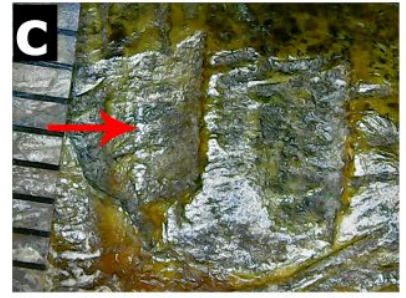
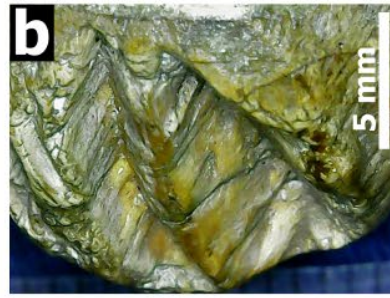
ID	No. of faces	No. of verticle	Height, cm	Width, cm	Thickness, cm	Resolution (size of 1 3D triangle)
F1	15 643 240	7 821 622	14,2	4,2	4,1	60
F2	7 145 438	3 585 501	10,5	1,8	1,6	33
F4	29 276 012	14 694 168	7,1	4,4	4,1	30
F5	24 432 546	12 216 275	5,2	3	3	25
F8	12 135 530	6 090 475	3,2	1,8	1,6	65
F18	14 613 252	7 306 628	5,9	1,7	3	75

Supplementary Table 9. Alignment parameters of 3D models

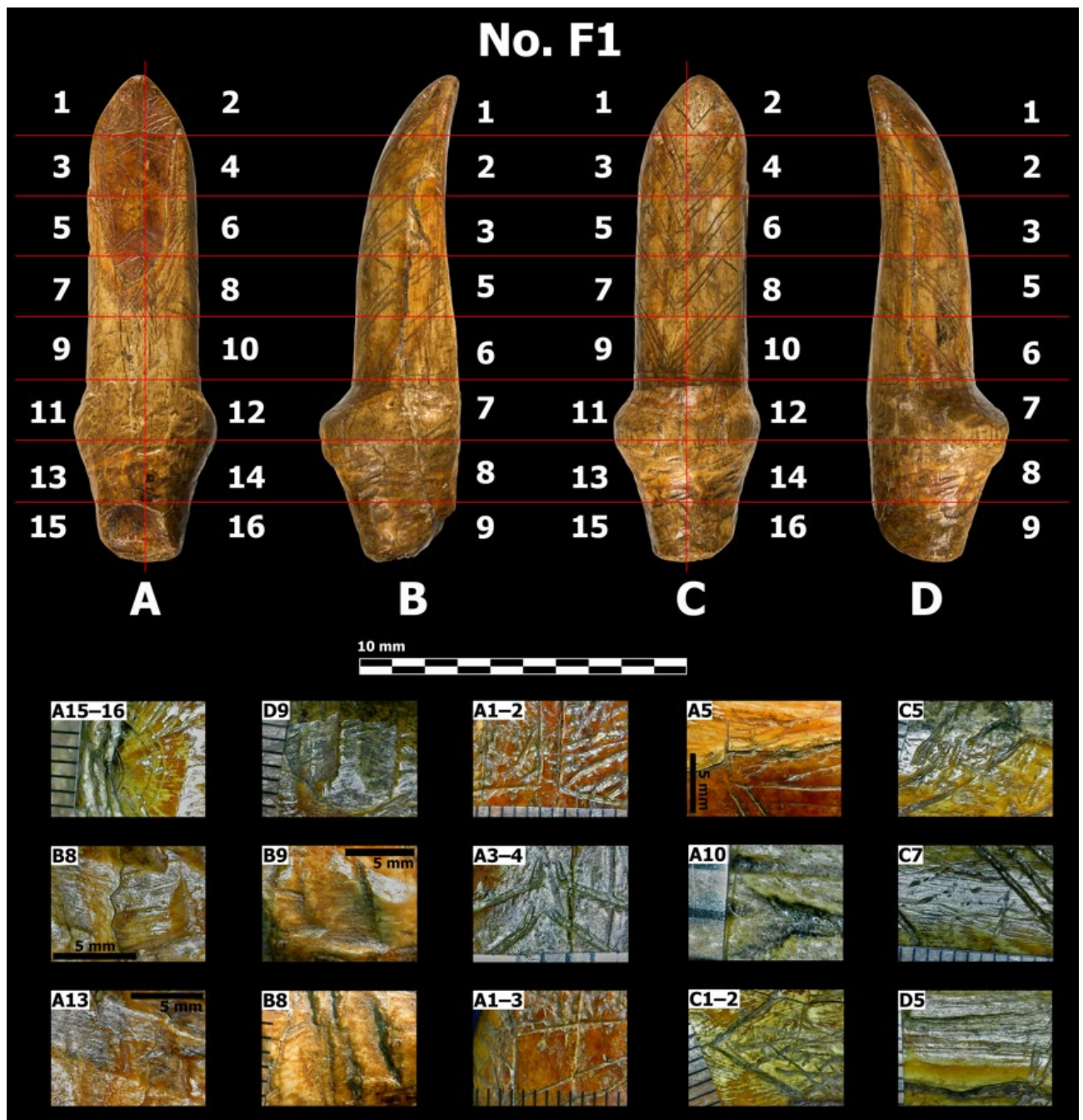
ID	Point count	Total projections	Mean error, pixels	Total alignment time	Alignmen t mode	Max. feature reprojection error	Final optimization	Meshing quality	Total processing time
F1	750 744	3 152 232	0.491699	19 s	High	2	Yes	High	45m 48s
F2	277 826	1 277 103	0.518674	1m 14s	High	2	Yes	High	50m 28s
F4	680 555	2 987 402	0.51509	4m 8s	High	2	Yes	High	1h 7m 46s
F5	458 760	1 926 514	0.527587	5m 38s	High	2	Yes	High	28m 32s
F8	165 319	630 907	0.480485	34s	High	2	Yes	High	15m 51s
F18	296 640	1 094 374	0.477249	2m 4s	High	2	Yes	High	49m 24s

Supplementary 6

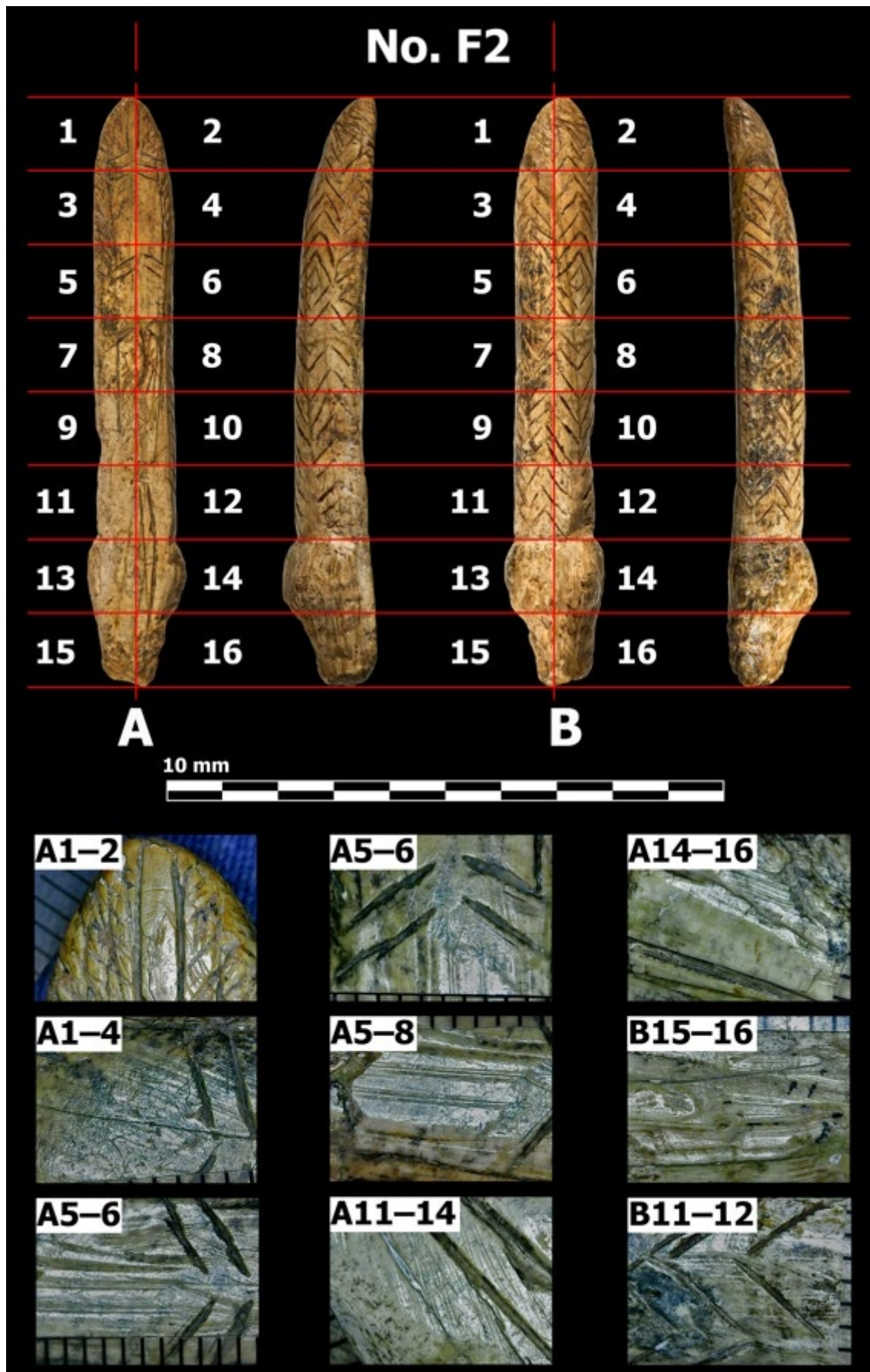
Microscopic examination visual summary samples



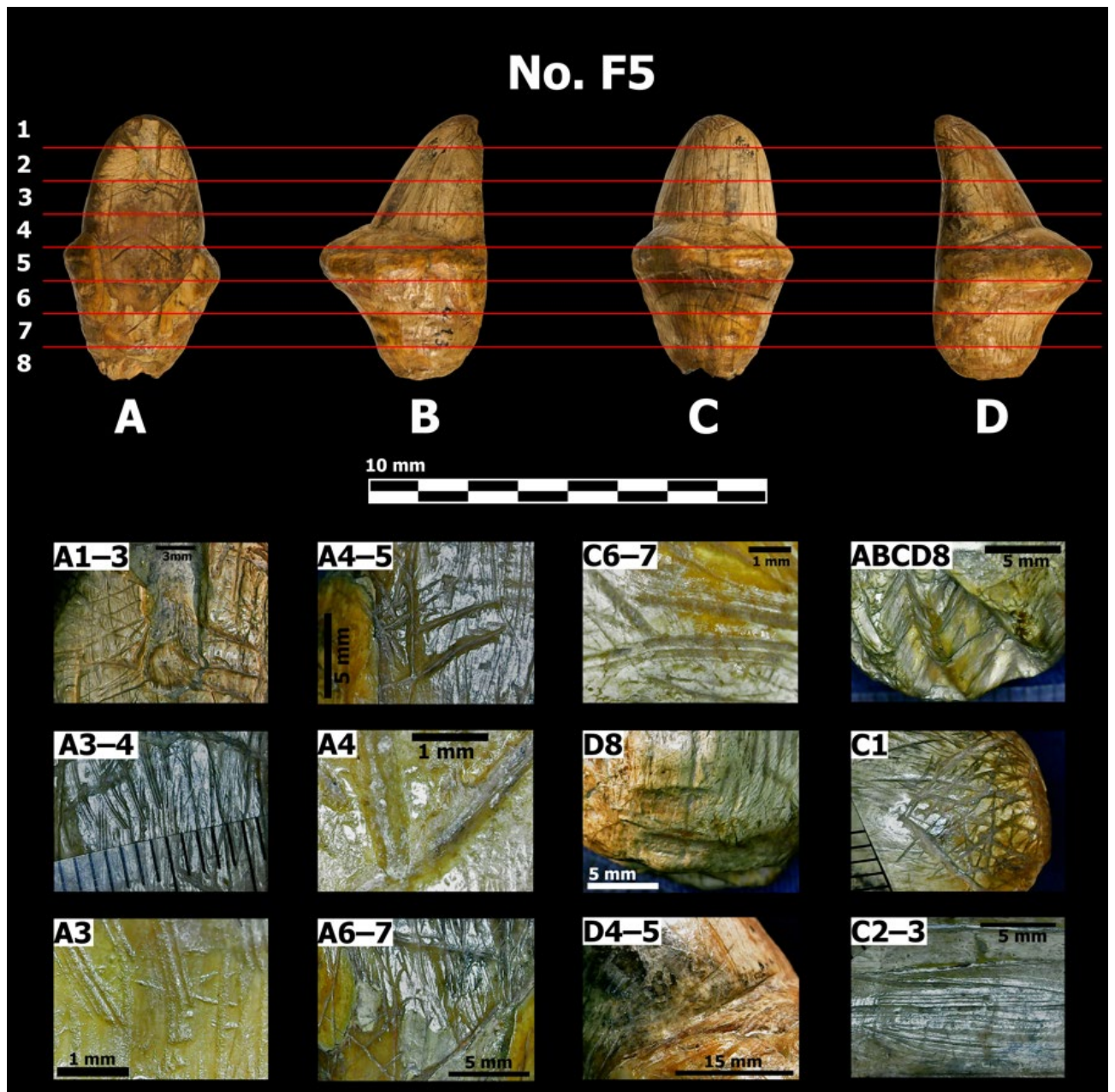
Supplementary Figure 10. Surface modifications on Mizyn figurines. Red arrows indicate movement directions; blue arrows mark features of special interest. a – Owen lines in the lower part of the figurine F1; b – traces of initial blank extraction, F5; c, d – planning traces with tools possessing robust, sharp edges (blades with feather-like edges or wedges on blades (piece esquille)); e, f, g, h – scraping traces made with tools having sinuous edges (retouched blades type or scraper (e)) or with robust, blunt working edges (trimmed or broken blades, burins (f, g, h)); i – traces of abrasive processing; j – a planning (layout) groove in the medial area of the figurine; k – upper part of the anthropomorphic silhouette with “head-neck” and “hair” (Notably, the interior of the anthropomorphic figure remains clean, suggesting the use of preliminary layout lines to keep the “hair” engravings, applied earlier, outside the contour); l – lower part of the anthropomorphic silhouette (note fine scratches beneath each of four cuts. These may result from working edge damage of the tool, though intentional incision for layout purposes cannot be ruled out); m – a thin stroke with a V-shaped profile cuts into a wide groove with a U-shaped profile. The engraving sequence suggests a tool change; n, o – traces of heavy damage to the tool’s edge; p – surface damage due to a possible figurine’s use; q – damage leading to a partial loss of a pubic triangle. The surface was smoothed after the damage; r – possible traces of the groove renovation after the polishing. Photos by Oleksandr Naumenko



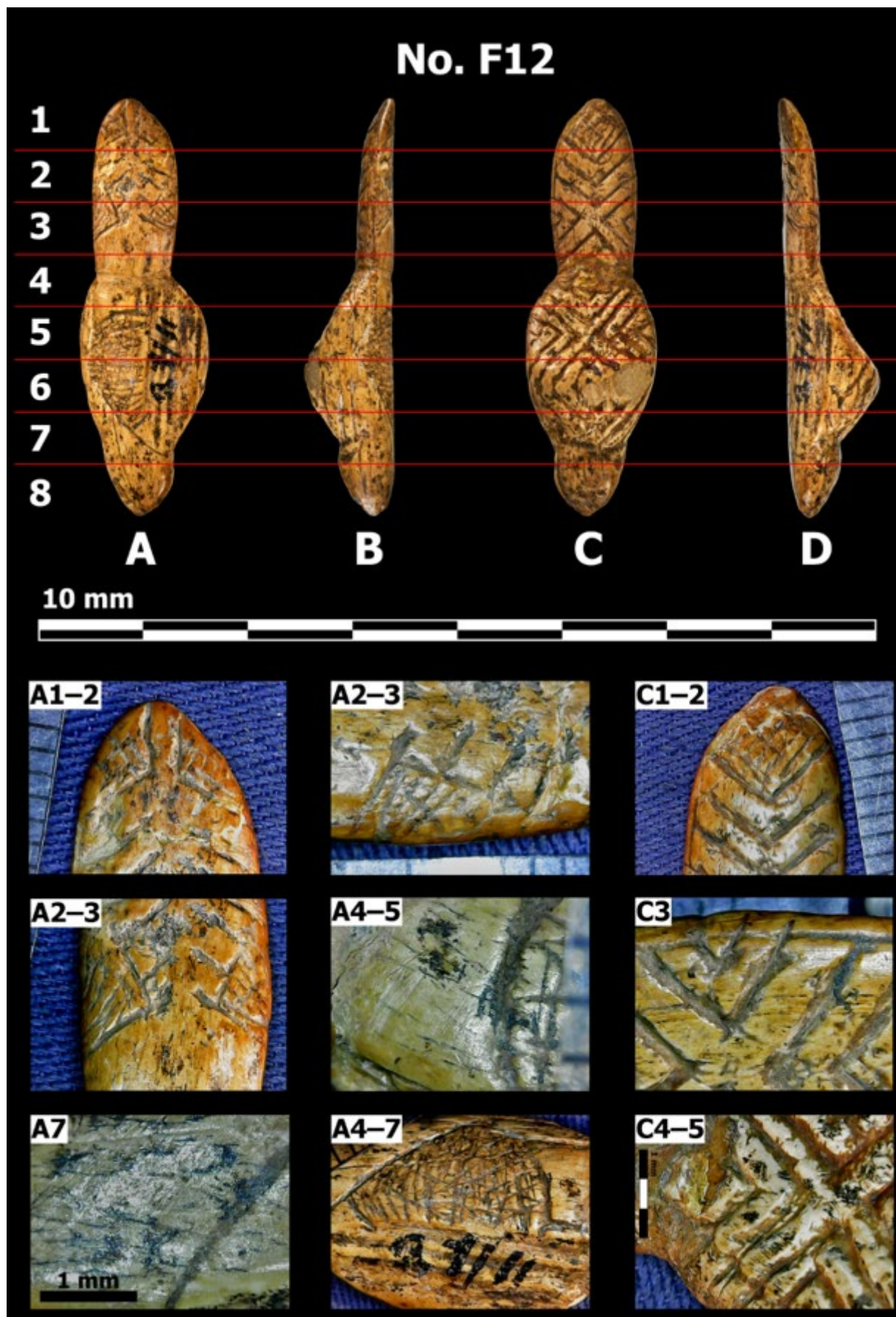
Supplementary Figure 11. Microscopic observation results for the figurine F1. Specific observation zones are marked as quadrants according to the scheme in the top part. Macroimages of points of interest in these quadrants are below.



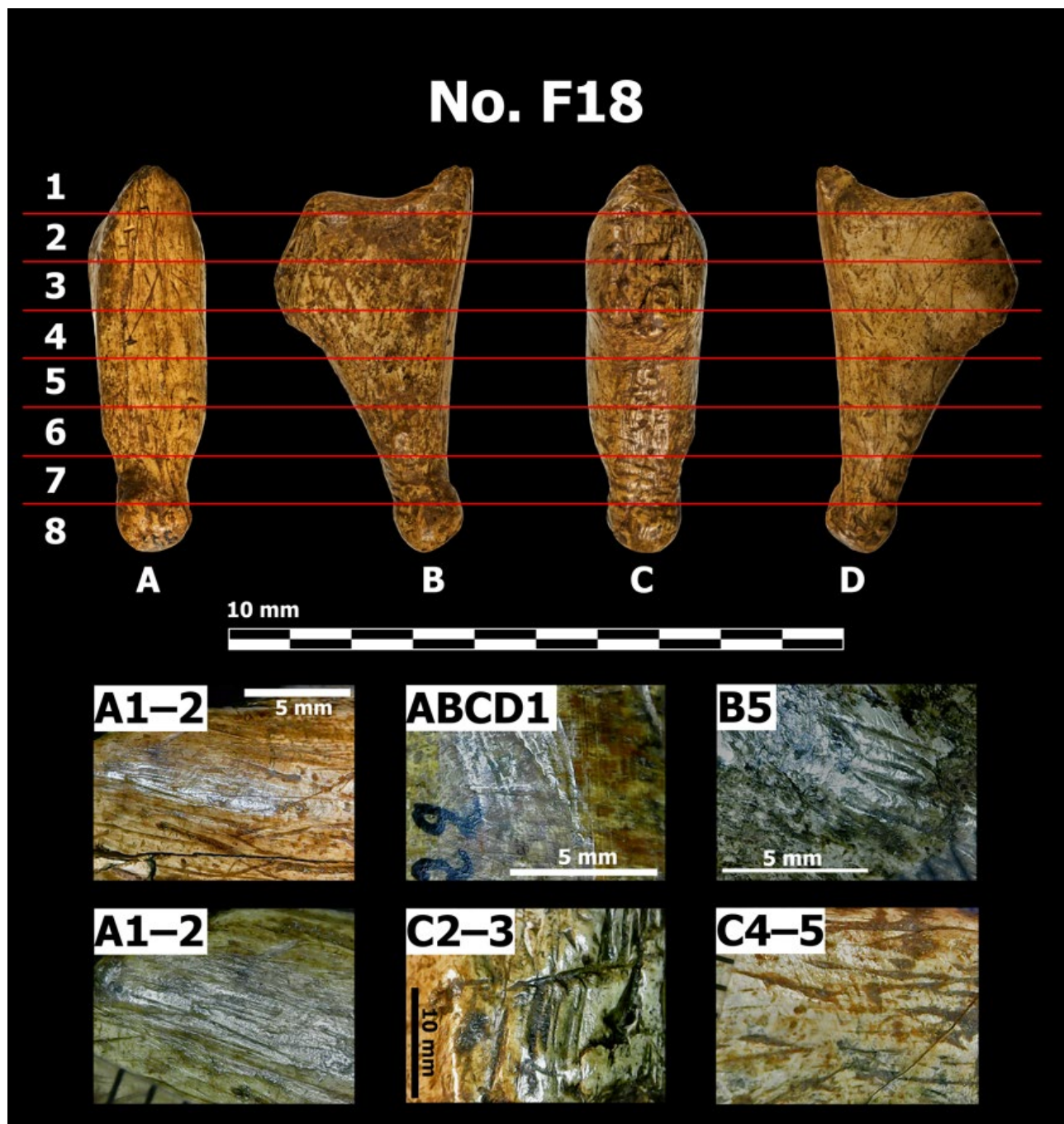
Supplementary Figure 12. Microscopic observation results for the figurine F2. Specific observation zones are marked as quadrants according to the scheme in the top part. Macroimages of points of interest in these quadrants are below.



Supplementary Figure 13. Microscopic observation results for the figurine F5. Specific observation zones are marked as quadrants according to the scheme in the top part. Macroimages of points of interest in these quadrants are below.



Supplementary Figure 14. Microscopic observation results for the figurine F12. Specific observation zones are marked as quadrants according to the scheme in the top part. Macroimages of points of interest in these quadrants are below.



Supplementary Figure 15. Microscopic observation results for the figurine F18. Specific observation zones are marked as quadrants according to the scheme in the top part. Macroimages of points of interest in these quadrants are below.