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River Paradigm for Sedentary Mammoth Hunters

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Abstract

This paper proposes a new interpretive framework for Upper Paleolithic woolly mammoth (*Mammuthus primigenius*) procurement in Central and Eastern Europe, termed the River Paradigm (RP), through a comparative systems analysis of archaeological, taphonomic, iconographic, economic, spatial data, and evidence. The model argues that sedentary mammoth-hunting communities associated with multi-purpose mammoth-bone structures (MMBS) exploited navigable river systems for the procurement, transport, butchery, processing, and storage of woolly mammoths. Evidence for this interpretation derives from the primary archaeological data and five engraved ivory and bone process charts from Mezhyrich, Eliseevichi, Kyiv-Kirilovskaia, Molodova I–Layer 4, and Předmostí, interpreted here as process charts or

operational depictions of mammoth procurement and processing activities. Particular emphasis is placed on the perfect correlation between MMBS settlements and navigable rivers, the widespread representation of many complete disarticulated individual mammoth skeletons in taphonomic assemblages and inventories, and the tactical elevation reversal when mammoths entered rivers.

The study evaluates the logistical feasibility of alternative existing terrestrial procurement theories through comparative analyses of transportation energetics, carcass mass, labor requirements, foraging radii, predator risk, and skeletal representation within mammoth megasites. These factors collectively suggest the impossibility of overland transport of complete mammoth carcasses and provide critical support for river-assisted procurement and transport.

The paper further argues that conventional reconstructions and depictions of Upper Paleolithic mammoth hunting—typically emphasizing close-range terrestrial spear hunting—do not adequately account for hunter safety, the power, height, and size disparities, the scale of mammoth-bone accumulations, transportation logistics, or the spatial organization of processing activities observed at mammoth mega-sites. Instead, the River Paradigm, based on archaeological and physical facts, demonstrates dramatic reversal of tactical and terrestrial advantages and disadvantages when mammoths were hunted in rivers. The proposed coordinated riverine subsistence system involved safe riverine hunting, powerful spears, elaborate river traps, downstream carcass transport, riverside butchery, specialized processing facilities, and long-term storage of processed meat and fat. This study proposes the widespread use by sedentary mammoth hunters of riverine killing zones and massive lubricated pre-positioned hafted composite thrusting spears such as those believed employed at Předmostí.

By integrating iconographic evidence and facts with systems-based archaeological analysis, this study addresses longstanding questions concerning mammoth procurement strategies, hunting techniques, weapons, the function of mammoth-bone structures, and the broader organization of Upper Paleolithic mammoth paleo-economies.

Keywords: Mammoth-bone structures, palaeoeconomy, ivory process charts, Mezinian Culture, rivers, mammoth hunting

Methods

Research Approach. The research leading to the development of the River Paradigm (RP) was conducted independently and outside many of the physical, site-specific, temporal, budgetary, institutional, and administrative constraints that commonly shape contemporary archaeological and anthropological investigations.

Identification Through Internet-Based Research. As Dr. Speth observed of one of his own publications, this study is, in many respects, a “child of the Internet.” As Dr. Binford noted, “Advances have generally been made through the discoveries of new materials and not by virtue of the successive growth of knowledge that generally accompanies the use of scientific methods” (Binford 1981: 292). The author does not claim any archaeological discoveries in the conventional sense. Rather, the contribution of this study lies in the identification, interpretation, and analysis of previously published evidence, including archaeological drawings that are here interpreted as five Paleolithic process charts not previously

recognized as such. The evidence supporting the River Paradigm was assembled from published studies, journal articles, books, archaeological reports, maps, photographs, drawings, and online resources. Even where specific interpretations or hypotheses advanced by previous researchers are challenged, the underlying observations, data, and documentation provided by those scholars remain important sources of evidence supporting the RP.

Process Chart Identification. By the time the three Mezinian ivory process charts were made, mammoth hunters had been carving or incising figures on tusk ivory for over 375,000 years. (Stepanchuk & Naumenko, 2025). Ivory with its prized characteristics was during most times a durable and suitable material for representational and abstract art on portable objects. (Heckel, 2009). The ivory process charts were *not* the more common personal ornaments, beads, jewelry, Venus figurines, specialized tools, depictions of single or live animals or humans, depictions of one thing, portable art (excepting the Kyiv-Kirilovskaia Process Chart), or simple repeated designs, which puts them in a class by themselves. (Cf. Bednarik, 2013; Svoboda, 2007). Carvings around the entire circumference of a tusk segment, like the Kyiv-Kirilovskaia Process Chart and Pavlov Map, are similarly rare. Most exceptional is the depiction of dead mammoths, when all or virtually all of the other mammoth depictions in Paleolithic art, including the Kyiv-Kirilovskaia Process Chart, are of alive, upright mammoths. (Lioubine, 1999; Vereshchagin & Tikhonov, 1999).

The artistic and somewhat abstract and deconstructed Kyiv-Kirilovskaia Process Chart was identified thanks to the Iakovleva Drawing of that ivory tusk segment (Fig. 3; Iakovleva, 2016: Fig. 6b). Kyiv-Kirilovskaia is 100 km from Mezhyrich. (Soffer, 1985: Table 4.7).

The Molodova I-Layer 4 Process Chart was found in the Chernysh Drawing of the mammoth scapula found at that site and published by Nowell & d'Errico (2007). (Nowell & d'Errico, 2007: Fig. 17(b))@ https://eclass.uoa.gr/modules/document/file.php/ARCH164/The_Art_of_Taphonomy_and_the_Taphonomy_o.pdf

The Předmostí Chart was identified as such after study of Svoboda (2017), which contains that chart.

Ivory was a preferred material for Paleolithic depictions (Heckel, 2009). Three of the pictographic ivory process charts were created in the Mezinian mammoth-hunting culture between 19,000 and 17,500 cal BP, within the Middle Dnieper River drainage basin. (Djindjian & Iakovleva, 2021:122 as to inclusive dates; Gleissner, 2025). The physical and chemical properties of mammoth ivory—soft enough to incise, score, or carve yet dense and durable over time—enabled preservation of the Kyiv-Kirilovskaia tusk segment under some 13 to 22 meters of soil. (Soffer, 1985: 65). The inconspicuousness of faint lines in the Molodova I-Layer 4 Scapula Process Chart demonstrates the superiority of ivory over bone for these charts.

Progress of Research. Research initially focused on evaluating the possibility that many mammoth-bone circles functioned as smokehouses. During a review of Paleolithic imagery, a depiction interpreted as a mammoth carcass floating in a river was identified in one version of the Mezhyrich Map and later a plaque from Eliseevichi. Additional features were interpreted as cords securing the carcass to the riverbank, disarticulated bones along the shore, four structures previously identified by Pidoplichko as dwellings (three of which he excavated), an apparent route connecting the river to the settlement, and four elevated storage features interpreted here as meat/fat caches. These observations led to the development of

the River Paradigm as a working hypothesis. As research progressed and climbed a wall of rejections, four additional drawings were identified and interpreted as process charts depicting stages of riverine mammoth procurement and utilization.

With the exception of the Square Projected Photograph (Fig. 1a) of the Kyiv-Kirilovskaia Process Chart, the drawings of process charts by archaeologists, as to each of the five process chart drawings referenced, were much more informative than photographs of the process charts themselves. Many portions of each photograph or microscopic view are obscured by curved ivory surfaces, deterioration, some weak or shallow incisions and re-incisions, contamination, smudges, long burial underground, discoloration, poor photographic lighting, older photographic technology, and broken ivory. Drawings of each of the five charts reveal the most information but are necessarily inexact. There are multiple similar drawings of the Mezhyrich Process Chart, one without full depiction of the mammoth, but the museum drawing of same shows the important process steps. (Gleissner, 2025: Fig. 3 @ https://juniperpublishers.com/gjaa/GJAA.MS.ID.555888.php). Minute, faint, and tiny incisions required magnification and then hand-drawing. The black lines in drawings are much more visible than the faint lines incised on ivory and bone.

Development of the River Paradigm. The River Transport Hypothesis, first published in July 2025, proposed that mammoths were procured in riverine environments, transported by water to settlements, butchered in or adjacent to rivers, and subsequently processed in nearby facilities suitable for smoking meat and rendering fat. The companion Smokehouse Hypothesis proposed that large mammoth-bone structures characterized by multiple flat hearths arranged along a northwest–southeast axis and abundant burned bone functioned as smokehouses designed for large-scale meat and fat processing. As evidence accumulated in support of these related hypotheses, they were integrated into the broader interpretive framework presented here as the River Paradigm.

Sequential System Model. A sequential system model within the River Paradigm (§11.0) was developed to reconstruct the most probable sequence of chase zone, killing zone, and transport zone preparation and then procurement, transport, processing, storage, and utilization activities consistent with the archaeological record and relevant scholarly literature.

Research Questions Addressed. Existing terrestrial models have generated a range of interpretations, including scavenging, bone collecting, *in situ* herd kills, and seasonal movements to mammoth bone accumulations as sources of construction material. The River Paradigm offers an alternative explanatory framework for understanding how Paleolithic communities accumulated large quantities of mammoth remains at settlement sites. By integrating procurement, transport, processing, and storage into a single river-based system, the RP seeks to address several longstanding questions in mammoth archaeology and to provide a more coherent explanation for the archaeological evidence.

1.0 Introduction

The mammoth-hunting cultures that constructed multi-purpose mammoth-bone structures (MMBS) near navigable rivers before, during, and after the Last Glacial Maximum occupied a vast territory extending from the Central European sites of Předmostí, Milovice, Pavlov, and Dolní Věstonice in the Czech Republic; Grub-Kranawetberg, Krems-Wachtberg, Krems-Hundssteig, and Langmannersdorf in Austria; Kraków Spadzista in Poland; and Molodova I, Layer 4, on the Dniester River

in Ukraine. Their distribution continued eastward across the Russian Plain, encompassing the Middle Dnieper Basin sites of Mezhyrich, Mezin, Kyiv-Kirilovskaia, and Eliseevichi, and ultimately reaching the twenty-six Kostenki-Borshchevo sites situated along the Don River in Russia.

Although the cultures occupying this extensive region over many millennia possessed diverse lithic traditions, those associated with MMBS shared a pronounced economic focus on the woolly mammoth (*Mammuthus primigenius*) and exhibited the characteristic physical and organizational features of MMBS settlements. In areas adjacent to the Carpathian Mountains, hunters at various times specialized more heavily in reindeer, horse, and other non-proboscidean species. Nevertheless, the Moravian Gate formed an important migratory corridor for mammoths, while the open mammoth-steppe environment, characterized by extensive grasslands and high solar exposure, supported intensive mammoth hunting (Demay et al. 2021a: Fig. 14).

Through detailed investigations of Upper Paleolithic mammoth-hunting societies, archaeologists have posed several fundamental questions concerning the communities that constructed MMBS. How were these structures used? How did the mammoth palaeoeconomy function? What were the origins of the large bone accumulations found at settlement sites? Were these accumulations the result of geological processes, natural mortality, scavenging, or deliberate hunting activities? These questions remain central to understanding Paleolithic subsistence systems and settlement organization (Demay et al. 2012; Djindjian 2015; Pryor et al. 2020; Shipman 2015a). As Iakovleva (2016) emphasized, the primary scientific objective is understanding the system that generated the archaeological record.

The River Paradigm (RP) was anticipated by earlier suggestions that the Pavlovian, eastern Gravettian, and Mezinian sites may have formed part of a broader economic system centered on mammoth exploitation. As Iakovleva et al. (2012) observed, “It is useful to wonder if the Pavlovian, eastern Gravettian and Mezinian sites do not belong to a more general system specializing in the economy of mammoth.” The River Paradigm proposes such a system and seeks to provide answers to several longstanding questions concerning mammoth procurement, transport, processing, storage, and utilization. This paper builds upon the hypotheses, models, evidence, and systems analysis presented in the author's earlier study, *Explaining the Mammoth Economy, Smokehouses, and the Mezhyrich Map* (Gleissner, 2025). Readers are encouraged to consult that work (and correcting errata herein) as foundational background for understanding the development and scope of the River Paradigm.

Several previously unrecognized process charts play an important role in the present analysis. The Kyiv-Kirilovskaia Process Chart was identified with the aid of the Iakovleva Drawing (Fig. 3; Iakovleva 2016: Fig. 6b) and is interpreted here as illustrating detailed stages of fat-rendering and cold-smoking. The Molodova I, Layer 4, Scapula Process Chart was identified from a drawing published by the late Professor Oleksander Chernysh (1918–1993) (d’Errico et al. 2011). In addition, the Předmostí Riverine Hunting Map Process Chart (“Předmostí Chart”) was identified as a terrestrial killing zone in a publication by the late Dr. Jiří A. Svoboda (2017). Together, these process charts constitute a significant body of reliable visual evidence prompting and then supporting the interpretations advanced in this study.

2.0 Data Supporting the River Paradigm

2.1 **Too Heavy To Move by Land**. The weight of young adult and adult woolly mammoth (*Mammuthus primigenius*) carcasses ranged from about 2,000 kg to 4,000 kg for females and 6,000 kg for males, and in very rare cases up to 8,000 kg, some 50 to 120 times heavier than the weight of Paleolithic

mammoth hunters at about 67 kg. This weight and strength differential challenged mammoth hunters, governed hunting tactics and the movement of carcasses or mammoth parts, and barred movement of whole mammoth carcasses on land by humans (Anatomically Modern Humans, AMH, *Homo sapiens*) or Neanderthals (*Homo neanderthalensis*). The efficiency in energy expenditure and time of water transport versus land transport over uneven terrain is well-established in many contexts.

2.2 **Complete Taphonomic Representation**. "Upper Paleolithic sites are also much more likely to contain all parts of the mammoth skeleton (e.g. Wojtal and Sobczyk, 2005, Brugère and Fontana, 2009, Bosch, 2012)." (Shipman, 2015). "We strongly underline that all parts of the mammoth skeleton were identified in the Kraków Spadzista site assemblage." (Wojtal et al., 2025). The presence of all skeletal parts for multiple individual mammoths in the settlements with mammoth-bone structures begs the question how they came to be in one place, on land. In the Paleolithic era, the only physical force powerful enough to bring multiple whole individual woolly mammoth carcasses together in one place was the downstream movement of rivers, followed by butchery and disarticulation sufficient to permit minimal terrestrial transportation uphill to nearby settlements, structures, smokehouses, and bone beds, where the bones were found millennia later. If mammoths were transported on navigable rivers, then necessarily they were killed in rivers, to which mammoths are naturally attracted due to water and mineral requirements, migrations, social activities, and play. Complete taphonomic representation follows from the logistic impossibilities of moving entire mammoth carcasses (or even entire skeletons) by land.

2.3 **Perfect Correlation**. The perfect or near-perfect assumed correlation (r = 1.0) between mammoth-bone structures and nearby navigable rivers, as revealed in accurate maps and all archaeological excavations of MMBS, shows the invariable selection logic of organized mammoth hunters. They built MMBS beside navigable rivers in Central and Eastern Europe with favorable upstream hunting territories and acceptable climates. All 26 Kostenki-Borsheevo sites are on the Don River, while Mezinian sites are on rivers and tributaries in the Dnieper River Basin. Accurate maps of mammoth settlements with mammoth-bone structures reveal all are located on navigable rivers, with meandering, braided, or straight channels or floodplains. No mega-sites without navigable rivers have been found. Notable for this study were the MMBS located at rivers in the middle Dnieper River Basin (Gladkih, et al., 1984), which sites were protected by loess, have been studied extensively, and which represent one peak of mammoth-hunting culture.

A map of all Eurasia shows that all or nearly all of the inland mammoth sites, of all sizes and dates, regardless of culture or system, are on rivers. (Markova, et al., 2013: Fig. 2). Spy Cave, Belgium, where horse and reindeer were also taken, sits above the Orneau River. (GERMONPRÉ et al., 2014). The important Vézère Valley World Heritage Paleolithic sites are directly on and above the Vézère River in southwestern France. (UNESCO). Yana RHS is on the Yana River. Sites in the Middle Kolyma Basin are on the Kolyma River or its tributaries. (Chlachula, 2021). Modern Russian tusk hunters typically find tusks along rivers. The RP confirms that MMBS had to be on navigable rivers.

The *Mammuthus primigenius* remains (MNI = 28) from the Aurignacian cave deposit at Vogelherd, Germany were found 200 m from the Lone River (Niven, 2001), now a dry creek much of the time. But the Lone River was formerly a flood plain and might be presumed navigable at flood stage when the mammoths, horses, and other large mammals were taken. The Swabian Jura mammoth sites are located directly on the Lone, Ach, and Brenz Rivers. (Don's Maps, 2026). Swabian Jura Paleolithic hunters did not

need to build shelters out of mammoth bones, because caves were conveniently located near rivers. It is proposed *infra* that these hunters, regardless of human sub-species or culture, depended upon riverine mammoth procurement to the extent they left significant bone accumulations and artwork. Austrian mammoth sites are located on the Krems, Perschling, and Mur Rivers. Mammoth hunters with caves above rivers had less incentive to accumulate large inventories of bones.

2.4 **Hunting Advantages from Reversal of Tactical Elevation**. The River Paradigm (RP) flips the traditional view of Paleolithic hunting by highlighting how navigable rivers negated and then reversed a mammoth's advantages over hunters. On land, a 2,000 to 8,000 kg mammoth was a fortress against a 67 kg hunter. In water, heavy mammoths lost their footing, mobility, strength, and decision-making. They became subject to weightless buoyancy, river currents, and immersion in water well below the elevation of hunters and dogs. Mammoths fully out of their terrestrial element in flowing navigable rivers could not use their height, mobility, strength, weight, aggressiveness, vision, and size either defensively or offensively. This was particularly true of the more vulnerable younger and female mammoths weighing substantially less than adult males reaching 6,000 kg and only rarely 8,000 kg. Out of their terrestrial element, mammoths lost their physical and psychological dominance. The daunting terrestrial prey became a vulnerable riverine quarry.

In the Tactical Reversal Schedule in §11.0, the advantages lost by mammoths numbered 17, while the consequent advantages gained by hunters totaled 23. Mammoths gained nothing by entry into navigable rivers when pursued by hunters and dogs, and humans gained nearly every possible advantage under the RP. The reversal of advantages and disadvantages was nearly absolute, validating the RP, and undermining terrestrial mammoth hunting insofar as large mammoth bone accumulations are concerned.

After mammoths entered the river currents, mammoths and mammoth hunters each experienced an overwhelming literal and physical paradigm shift. The shift increased the effectiveness and safety of riverine procurement strategies and created nearly helpless mammoths. The planned structure and use of killing zones finalized the physical paradigm shift.

2.5 **High MNI as proof of productivity** & **efficiency**. The five (5) phases of the mammoth palaeoeconomy were determined by the riverine environment, the key data and facts, the very limited meat and fat processing and storage choices available, and by viewing the entire system as a production or manufacturing process producing smoked meat, rendered fat, probably pemmican (fully dried meat + rendered fat), and a variety of useful inedible objects. The RP is a system composed of sub-systems, sequential phases: hunting, transportation, tissue processing, and followed by storage in elevated meat/fat caches. These phases explain the well-organized mammoth palaeoeconomy. Sub-systems not discussed herein includes plant gathering and fishing.

Data for mammoth mega-sites confirms the productivity, use, and efficiency of the manufacturing process and system now termed the River Paradigm. High output establishes efficiency of the riverine procurement system. Mammoth MNI for the following selected mega-sites in Central and Eastern Europe are: Kraków Spadzista, Poland (confluence of Rudawa and Vistula Rivers, 113 MNI), Předmostí, Czech Republic (Bečva River, over 1,000 MNI per Musil, 2010), Dolní Věstonice-Pavlov-Milovice microregion (Dyje River, MNI 100+), including Milovice G, Czech Republic (21) (Wojtal, et al., 2018:Table 13), Eliseevichi, Russia (60) (Demay, et al., 2017:Table 5); Mezin, Ukraine (44), Mezhyrich,

Ukraine (109), and Yudinovo, Russia (35) (Shipman, 2015a: Table 1). The number of mammoth skeletons found at mammoth mega-sites by far surpasses the MNI found outside mammoth mega-sites and those reflecting no evidence of hunting. This study focused on Central and Eastern Europe, but the Northern Eurasian Arctic mega-sites seem to have the same general characteristics as those in Central and Eastern Europe.

Mega-site defined. Shipman defines mega-sites as having about 5 MNI mammoths up to over 100 MNI, cites five (5) mega-sites with single-digit MNI, and sought to determine how and why so many mammoth bones were collected in one place. (Shipman, 2015a).

2.6 **Provenance** & **Provenience**. The Provenience of all five process charts is reflected in the names of the settlements (mega-sites) where they were found and after which all five were named as process charts. The Provenance for each was that they were buried under loess at those sites until found by excavators and placed in museums. Provenance is bolstered by incisions in ivory, and one in bone, process charts. We know mammoth hunters incised or carved them and that they remained in the custody of mammoth hunters until abandoned on sites. The provenance and provenience of allegedly scavenged or collected bones under terrestrial procurement assumptions have never been shown. Support for the RP generally involves withdrawal of support for terrestrial acquisition relative to large bone accumulations.

3.0 Defining Characteristics & **Images of the River Paradigm System** (**RP**). Physical and operational characteristics help define the RP:

3.1 **Site selection on rivers**. The riverine environment drove and determined how mammoth hunters hunted and then processed their kills. All of the MMBS settlement base camps were founded on navigable rivers, sometimes near the confluence of two rivers, and within larger drainage basins avoiding the extremes of the Stahler Stream Order. Upstream warm-weather outposts were specialized hunting camps, also on rivers, sometimes to monitor and hunt paleo-fords. Temporary foraging camps likely existed for hunts or plant gathering in the mammoth steppe. Navigable rivers offered upstream hunting opportunities, paleo-fords, fishing resources, habitats for useful plants, and facilitated travel by boats, walking beside rivers, and walking or dog-sledding on frozen rivers. Site selection intentionally pre-determined all phases of the mammoth palaeoeconomy, invariably prioritizing river procurement, transportation, butchery and overall efficiency. Many sites were probably founded below one or more high-traffic paleo-fords. Some mammoths may have been brought to places on smaller rivers, but unless the river could support riverine hunting advantages and the floating of mammoths every year, MMBS were not likely built. Valea Morilor in Moldova was on a small river and had six mammoths represented. (Obada et al., 2012). Rivers may have been navigable for transportation of carcasses only during some weeks or months of the year. In Eurasia as a whole, rivers may have been navigable generally for hunting reindeer, horse, bison, and smaller mammoths but not adult male woolly mammoths as often or ever. Because very wide rivers could not be turned into killing zones easily, few of the mega-sites were located directly upon the widest of rivers, the Don River being a notable exception to this tendency.

Site Elevation Selection. Site selection criteria included elevation above rivers. MMBS were built on elevated terraces above rivers sufficient to withstand voluminous and destructive spring flooding. Higher ground restricts river meandering, results in straighter and deeper channels, and brought mammoths to a narrower segment of the river, which could be narrowed further with the structures like

those constructed at Předmostí. Most of the river valleys had meandering rivers at different places and times, since sediment built up and flattened the terrain, but at meander-limiting higher ground, settlements were founded. Předmostí can be seen as the transition between straight-channel mountain runoff to the subsequent meandering of the river. Mezhyrich, Kraców-Spadzista, Eliseevichi, Kyiv-Kirillovskaia, Mezin, Pavlov I, Gontsy, etc., and the Desna River sites (with few exceptions) are located on promontory terrain or the high right bank of the asymmetrical Desna River. While early thoughts suggested one reason was to keep a lookout for game, more basic considerations are the narrowing of the river channels near higher elevations and the long-accepted safety from flooding.

3.2 **Substantial MMBS**. Multi-purpose mammoth-bone structures (MMBS) with thick insulating walls indicated all-year habitation. Those MMBS could serve as fat-rendering stations, smokehouses, workshops, storage space, or meeting rooms for religious, civic, social, or ceremonial purposes. Purpose-built smokehouses with nine flat hearths running down the NW/SE axis were equivalent signifiers, although some of those may not have been insulated due to their sizes. Cold-smoking, drying, and fat-rendering could have been accomplished in portable chooms (tipis).

3.3 **Complete Taphonomic Representation**. Complete skeletal representation is discussed in §2.2 and constitutes one of the principal lines of evidence supporting the River Paradigm.

3.4 **Complete Reversal of Tactical Elevation Advantages**. Complete reversal of tactical elevation is discussed in §2.4 and constitutes one of the principal lines of evidence supporting the River Paradigm.

3.5 **Thoroughly Organized Efficient Economy**. The preparation for and execution of the five phases of the mammoth economy were systematically organized to maximize operational efficiency, control, and productivity, with each phase supported by structures and tools. The RP is supported by economic determinism, economic freedom, the necessity of using available techniques, and the profitability of the organized mammoth palaeoeconomy. Each phase of the mammoth palaeoeconomy was dependent upon the physical arrangements of the killing zone, and then each of the five economic phases; which in turn determined the physical handling of the subsequent economic or processing phase. The RP can best be understood now as an orderly manufacturing or processing system, with all phases, artifacts, terrain, and the multiple separate facts and evidence fitting neatly within the efficient explained production system. Mammoths were found alive and ended up as processed tissues in elevated meat/fat caches, useful bones, tusks, tools, insulation, etc. The profitability or success of the RP at any location can be judged simply by the number of mammoths taken, with the Mezinian Culture providing some of the highest production and Předmostí setting the record.

Under the River Paradigm, mammoth hunters let the rivers facilitate easier mammoth hunting, including heavy lifting, transportation, and security of the massive organic resource. Under Gall's Law (Gall, 2002), this complex system gradually evolved from simpler workable systems and did not arise fully formed at the beginning. The River Paradigm system had many more years to evolve than the modern systems made the subject of Dr. John Gall's work on systems engineering. Sedentary mammoth hunters had decades, centuries, and millennia available for the mature system to evolve from simple use of a thrusting spear. MNI data serve as a simple metric for the evolution of the River Paradigm system, although site selection and climate were sometimes overriding factors. The systems at Předmostí,

Mezhyrich, and Kraków Spadzista—three top mammoth harvesting sites per MNI at each site—might be regarded as using the most advanced systems during each of their eras.

3.6 **Common elements** & **images of the process charts**. All five process charts were discovered buried under loess, within drainage basins populated by Paleolithic woolly mammoths. Each process chart is unique as to some features, but all of the process charts contain the following common elements: Each depict (a) navigable rivers, (b) at least one phase of the Paleolithic mammoth economy; (c) objects clearly and exclusively associated with mammoth hunting in navigable rivers; and (d) images created on durable surfaces. Subsets of two, three, and four process charts contain many more common elements.

Common images in four of the process charts are: a river, a mammoth tied to the riverbank, ropes or cords, steps from river to structures (or obvious path in case of Mezhyrich), and disarticulated loose bones or tusks. The Předmostí Chart does not contain a mammoth, ropes, steps, or a MMBS but does show two riverbanks and structural improvements to the riverine killing zone. The three Mezinian ivories have in common multi-purpose mammoth-bone structures (MMBS) in one or more of several forms (dwellings, smokehouses, or fat-rendering stations); slopes (as steps or perspective) up from rivers; and long lines that might represent stored massive thrusting spears. Elevated meat/fat caches are identified only in the Mezhyrich and Eliseevichi Process Charts and were not multi-purpose structures. Unrecognized features and structures exist in all the charts. Slopes are easy to detect in the Mezhyrich and Eliseevichi ivories and recognized by superimposed steps in the Kyiv-Kirilovskaia ivory or from the perspective shown in Fig. 1a.

4.0 Kyiv-Kirilovskaia Ivory Process Chart (Mezinian/Epigravettian Culture)

The Kyiv-Kirilovskaia tusk ivory depiction is incised or carved on the distal end of a smaller mammoth tusk (Fig. 2), not on a plaque made from outer portions of a larger tusk as the ivory plaques from Mezhyrich and Eliseevichi were probably made. As is the case with all of the charts, a drawing of the tusk incisions reveals much more detail than any single photograph of the same object. The Kyiv-Kirilovskaia Process Chart (Fig. 3) is compared to the Pavlov Map by Svoboda (2017: Fig. 4). After millennia buried in loess, the four ivory artifacts on curved ivory required microscopic examination and then drawings of the fine but worn depicted features.

Except for Figure 1d, simple photographs (without projection of multiple photographs into two dimensions) of the ivories do not reveal much about the entire meat-processing scenarios depicted.

4.1 *Features and Spatial Data Points of the Kyiv-Kirilovskaia Process Chart.* Both the Iakovleva Drawing (Fig. 3) and the Square Projected Photograph (Fig. 1a) are projections of three-dimensional curved surfaces into two dimensions. The projected Iakovleva Drawing and the Square Projected Photograph in Fig. 1a share common elements with the other two ivory process charts. The Iakovleva Drawing, the Square Projected Photograph (Fig. 1a), and one simple photograph (Fig. 1d), *considered together* with knowledge of the RP, depict the following spatial or pattern data points or features:

4.1.1 tied tuskless mammoth

4.1.2 flowing river

4.1.3 one cold-smoking smokehouse & one fat-rendering smokehouse

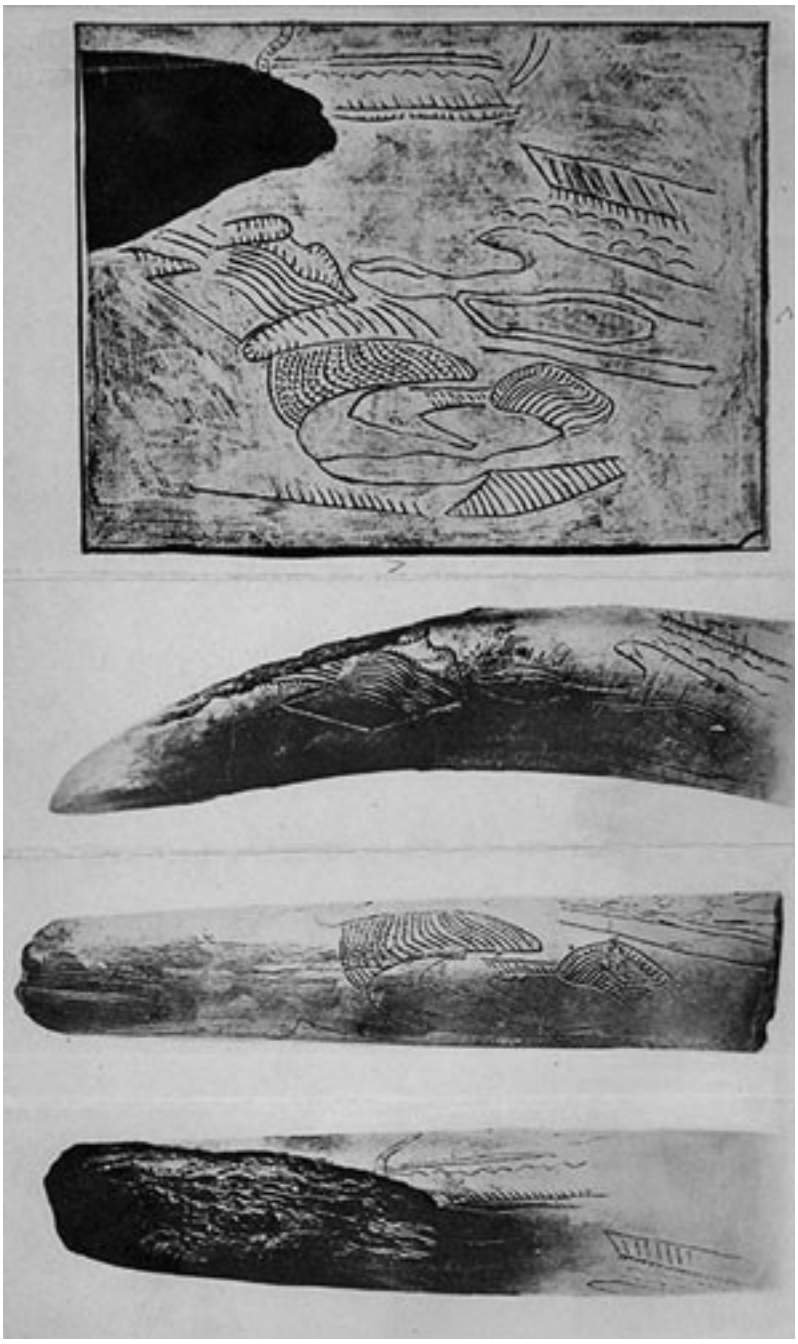
4.1.4 slope depiction

4.1.5 three (or more) ropes

4.1.6 disarticulated rib bones

The Square Projected Photograph (Fig. 1a), made from multiple photographs of the Kyiv-Kirilovskaia tusk is directly below, followed by three simple photographs of the same tusk segment (Fig. 1b, 1c, 1d).

1a



1b

1c

1d

Fig. 1 Kyiv-Kirilovskaia Tusk Photographs including Fig. 1a, 1b, 1c, 1d

4.1.1 *Tied Tuskless Mammoth*. The stylized but detectable mammoth (Fig. 3, 3a, different perspective in Fig. 1a) is the most recognizable and emphatic feature in the Iakovleva Drawing of the Kyiv-Kirilovskaia Process Chart (Iakovleva, L., 2016: Fig. 6b). The mammoth is depicted in a left side profile view, tied with rope by the trunk end, and that rope is secured by three stakes in the riverbank ground. (Fig. 3, 3a). The left eye resembles the numeral "2." (Fig. 3, 3a). The mammoth shown standing up is surrounded by river, depicted by straight lines to the left and to the right by curved river lines with tiny markings, triangles, or notches all pointed downward. The mammoth profile is upright and squarely presented in the Iakovleva Drawing (Fig. 3, 3a) but faces (from a slanted position) the bottom right corner of the Square Projected Photograph (Fig. 1a). The Iakovleva Drawing displays aesthetically pleasing and distinct designs, details, lines, and patterns (Fig. 3) not visible in the Square Projected Photograph (Fig. 1a) or in the detail of any single photograph.

The depicted tied mammoth is surrounded by blank space, white in the drawings, and the edges of that blank space appear to provide the larger profile of a mammoth parallel to the one depicted.

The whimsical appearance of the standing mammoth tied at the end of its trunk takes on a more realistic appearance suggestive of a hunting method when one views photographs of submerged swimming elephants with only their trunk-snorkels out of the water.

4.1.2 *Flowing River.* The stylized river is depicted in three successive styles or motifs of curved parallel lines (Fig. 3) and appears to be crossed or covered in two places. The river is depicted with clean curved parallel lines, except for the central segment, which displays detailed regular notches or small triangles on each line, and is suggested to represent water flowing over or around the partially submerged mammoth. (Fig. 3, 3a, 3b, 3c). The flowing river is best appreciated in the Square Projected Photograph (Fig. 1a). The small lines at the end of the long rope align with the flow of the river, indicating perhaps that portion of the rope is under water. (Fig. 1a).

4.1.3 *Cold-smoking Smokehouse & Fat-Rendering Smokehouse*. The two different rhomboid/rectangular structures appear to have different designs and probably functions, which suggests one is a cold-smoking smokehouse and the other a fat-rendering smokehouse). The two different smokehouses are more easily identified in Fig. 1a at the top and upper right of the Square Projected Photograph (Fig. 1a) and also directly in Fig. 1d. Those structures are visible in Fig. 1d in their original artistic perspective.

Some short lines or nicks may symbolize fire. Billows of smoke are depicted in connection with each structure by short, curved lines (Fig. 1a & Fig. 3). The object appearing like a huge poultry wishbone in the top of Fig. 1a, to the right of center, may be portraying a mammoth skull with original or inserted tusks protruding.

Smokehouse. Inside the structure identified as a cold-smoking smokehouse (center top of Fig. 1a) are depicted smoke billows in one undulating line, representing smoke containment, with the billows near the depicted ceiling.

Fat-rendering smokehouse. The upper right structure in Fig. 1a can be seen as a fat-rendering smokehouse with larger and hotter fires than in the cold-smoking smokehouse. Inside the fat-rendering

smokehouse are probably representations of strips of subcutaneous fat (Fig. 1a). The strips of subcutaneous or other mammoth fat are portrayed as thicker lines. In the Iakovleva Drawing, the strips of rendered fat look like cross-ties in railroad tracks (Fig. 3). Edible portions of mammoths were half fat and half lean meat (Agam & Barkai, 2016), the same proportions as pemmican (Speth 2025); hence the presence of both fat-rendering and cold-smoking smokehouses is predictable in addition to, inside of, or as temporary uses MMBS or other structures.

4.1.4 *Slope Depiction.* The eight (8) roughly parallel lines in the Iakovleva Drawing, corresponding to the six (6) roughly parallel lines in Fig. 1a, viewed from the perspectives shown in Fig. 1a and Fig. 1d, can be interpreted as a slope. The slope begins with the longest single unencumbered line in the Iakovleva Drawing, which in that Drawing starts near the lower left corner and points to near the upper right corner, ending "in the air." That is the first of eight lines ending in the line forming the base of what is provisionally termed a fat-rendering smokehouse. The second and third lines from the bottom form a double line, as do the fourth and fifth lines from the bottom, and as do the sixth and seventh lines from the bottom (Fig. 3). All eight lines are only discernable in the Iakovleva Drawing, where the slope inclines upward towards the fat-rendering smokehouse in the lower right corner of the Iakovleva Drawing (Fig. 3). Four of the lines, two double lines, form what looks like an island (Fig. 3). The space between the second and third lines from the bottom hooks around the "island" and becomes the space between the seventh and eighth lines.

Slope depicted by superimposed steps. Slope is also depicted in a series of 14 superimposed steps (Fig. 3c). Those steps approach the end of what is termed the cold-smoking smokehouse (Fig. 3, 3c), similar to the 19 steps portrayed in the Eliseevichi Process Chart (Gleissner, 2025: Fig. 4) and consistent with the foot-steps portrayed in the Molodova I-Layer 4 Process Chart. Steps at all sites were a physical and frequent connection between river butchery and higher smokehouses. In the Iakovleva Drawing, the 14 steps start out at a 90-degree angle to the slope described with eight (8) lines, but if both structures were on the same or nearby level above the river, then both are uphill from the river. (Fig. 3, 3c). Slopes were a universal feature above navigable rivers chosen for mega-sites. The 14 steps to and from river level superimposed on portions of the Kyiv-Kirilovskaia Process Chart are *very similar* to the 19 steps shown in the Eliseevichi Process Chart)(Iakovleva, L., 2016: Fig. 6b cf. Gleissner 2025: Fig. 4), and not unlike the footsteps portrayed in the Molodova I-Layer 4 Scapula Process Chart. Walking uphill with portable mammoth parts was an extremely common repetitive activity for sedentary mammoth hunters.

Fig. **2**
Kyiv Kirilovskaia Process Chart Tusk Segment
(Iakovleva, L., 2016: Fig. 6a)
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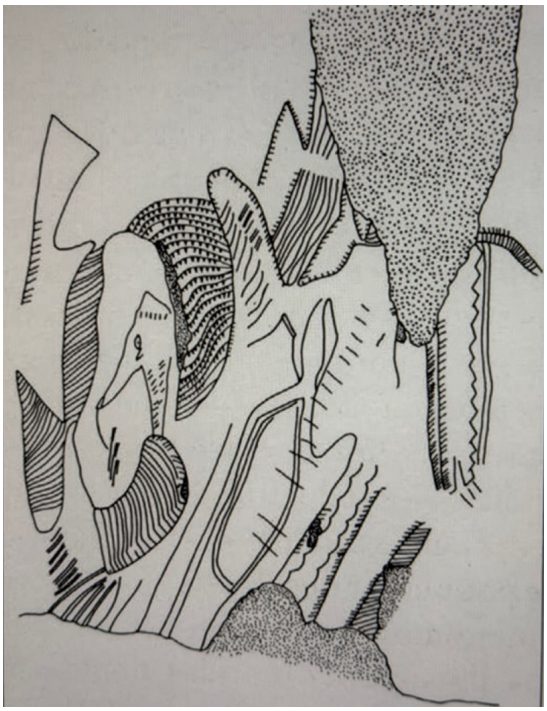

Fig. **3** – Iakovleva Drawing of the Kyiv-Kirilovskaia Process Chart
(Iakovleva, L., 2016: Fig. 6b)
Permission granted by Elsevier.

4.1.5 *Three or more ropes.* The long rope on the left side of the Iakovleva Drawing is interpreted by the author to represent one of the several cords used to secure floating mammoths to the riverbank below the Kyiv-Kirilovskaia settlement. The rope is drawn to arise from the river, which is consistent with the mammoth floating in the river. Another shorter rope is possibly depicted at the top of the Iakovleva Drawing, beside the non-descript large missing portion of the tusk and pointing in the same direction as the longer rope. A third rope, already mentioned, connects the mammoth trunk to three stakes in the ground. A rope from the base of the "lobster claw" runs to what looks like a short rib and then connects to the last long rib in that line. The "lobster claw" may represent tusks, although it connects to the terrain slope and remains unidentified.

4.1.6 *Disarticulated rib bones*. Disarticulated rib bones are depicted placed parallel to each other at two different places in the Iakovleva Drawing, and each grouping contains both large and small bones, with the large and small bones segregated in each of the two groupings (Fig. 3). The bones in each grouping are in parallel alignment but segregated into shorter and longer bones. One grouping is closest to the lower left corner of Fig. 3. The other grouping of butchered bones are also in parallel formation, short and longer segregated, on an abstract portion or "appendix" of land (or mammoth carcass) depicted over the river, in the center of the Iakovleva Drawing, barely into the top half of Fig. 3. (Iakovleva, L., 2016: Fig. 6b, the Iakovleva Drawing). The two groupings may stylistically represent bones removed during butchery and placed temporarily on the riverbank. The butchered bones are shown clean of meat and fat, which was not perhaps their condition immediately after butchery (Fig. 3). At most, the Iakovleva Drawing

587 depicts 30 rib bones out of the 40 rib bones woolly mammoths possessed (Fig. 3). Larger mammoth bones
588 are not depicted, probably due to space concerns, nor is a tusk clearly discernable (Fig. 3).
589

590
591 **Fig**. **3a –** Close-up of tied tuskless mammoth profile in Iakovleva Drawing. Permission granted by Elsevier.
592

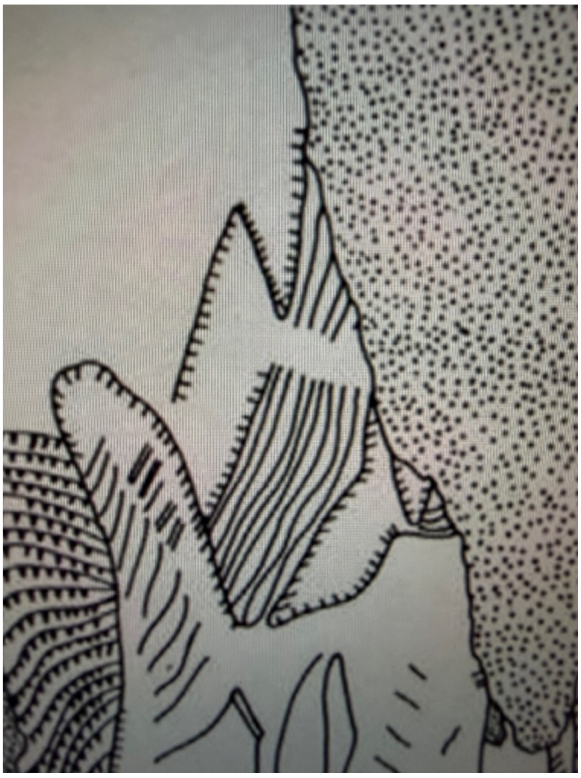

Fig. **3b –** Close-up of Iakovleva Drawing: Small bridge (?) across river depicted by absence of river lines, perhaps from shore to carcass or to missing portion of tusk. Permission granted by Elsevier.

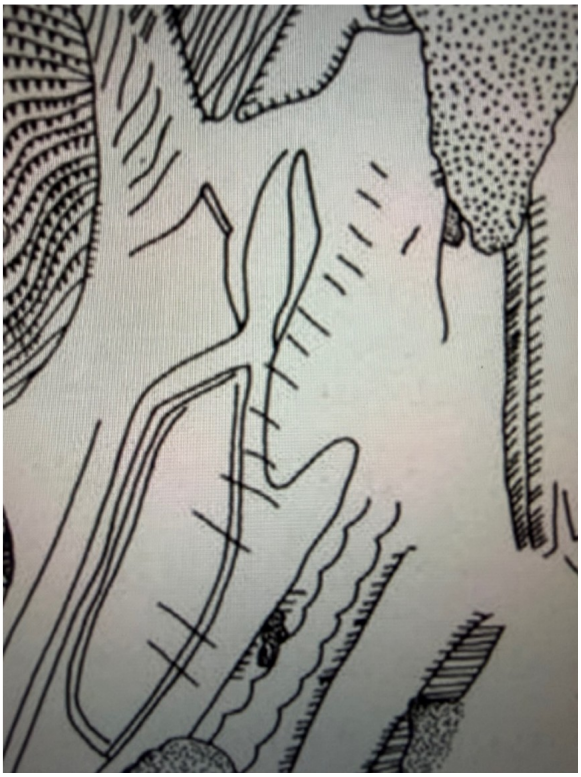

Fig. **3c** Close-up of Iakovleva Drawing: Showing 14 steps to and from river level superimposed on portions of the Kyiv-Kirilovskaia Process Chart, similar to the 19 steps in the Eliseevichi Process Chart)(Iakovleva, L., 2016: Fig. 6b). The "island" and "lobster claw" may or may not be terrain features. Permission granted by Elsevier.

The Kyiv-Kirilovskaia Process Chart lacks perspective due to the tight conical shape of the ivory tusk, space limitations, and abstract deconstructed depiction. Projection into the two-dimensional Square Projected Photograph adds perspective consistent with the topography of MMBS sites. Comparison of Fig. 1a to Figures 1b, 1c, and 1d demonstrates the difficulty of interpreting a curved process chart incised on the outside of a smaller tusk and also the necessity of Iakovleva's Drawing (Fig. 3) for detail.

The Iakovleva Drawing is much finer and more detailed than the image displayed on the Square Projected Photograph (Fig. 1a), in the poor Soffer photograph of the same tusk segment (Soffer, 1985: Fig. 2.54), in the color photograph of the tusk segment (Fig. 2), or in the cruder drawings of the Mezhyrich and Eliseevichi ivory process charts. (Gleissner, 2025: Fig. 3 & 4). The layout and position of the Square Photographic Projection (Fig. 1a) provides a perspective of the river running down from left to right and smokehouses or fat-rendering stations at the top (Fig. 1a). The square photographic projection (Fig. 1a) can more easily be viewed as a butchery scene in the river, corresponding to scenes in the Mezhyrich and Eliseevichi Process Charts. The two structures in Fig. 1a, presumably a cold-smoking smokehouse and a fat-rendering smokehouse, are not discernable as such in the Iakovleva Drawing. Although actual butchery is not depicted, the cameo profile of the tied and docked mammoth (standing up), the loose butchered bones arranged in parallel fashion, the depicted destinations for meat and/or fat, and the known proximity of butchery to smokehouses and fat-rendering stations leaves little doubt of butchery (Fig. 1a, 3, 3a). The most definite depiction of a mammoth is in the Iakovleva Drawing, but the stylized profile image is of a live mammoth, not one being butchered in the river as in the two ivory plaques.

The Kyiv-Kirilovskaia artist had to deconstruct the scene because there was not nearly enough space to carve or incise a river and settlement landscape perspective in one view as the flatter (but still curved) ivory plaques provided (Gleissner, 2025: Fig. 3 & 4). The scenes depicted were on opposite sides of the tusk, so a singular perspective or small map was physically not possible or practical. The river is shown flowing under an extended land form, riverbank, or "appendix" with butchered bones placed in parallel order (Fig. 3, 3b). The river goes under a possible walkway, plank, or perhaps tree in the back of Fig. 3, defined by the straight river lines whose ends form opposing straight lines perpendicular to the flow of the river (Fig. 3, 3b).

4.2 **Pavlov Map**. An engraved or incised distal mammoth tusk segment from Pavlov I, the Pavlov Map, is said to depict the Dyje River and nearby hills (Fig. 4). The artistic value of the Pavlov Map equals the artistic value of the Kyiv-Kirilovskaia Process Chart, and both items are carved on distal portions of tusk. A river butchery or meat processing scene does not appear in the artistic and stylistic Pavlov Map (Fig. 4) tusk carving. All of the meaningful ivory and bone objects discussed herein feature rivers.

Fig. **4** Pavlov Map (37cm length)
Petr Novák, Wikipedia Creative Commons Attribution-Share Alike 2.5 Generic license.

4.3 **Oblonnia**, **Ukraine Tusk**. A partially incised ivory tusk was recovered from the Oblonnia archaeological site, although its incomplete and deteriorated conditions limited interpretation of the scant engraved motifs. No significant information or recognizable feature was derived by the author from its limited non-descript ornamental patterns and isolated long lines. The bare outline of a river may be represented with three long lines. Most of this tusk is unworked per examination of photographs. [https://www.encyclopediaofukraine.com/display.asp?linkpath=pages%5CO].

4.4 **Proposed Purpose of Tusk Ivory Items**. All five process charts are histories, Paleolithic depictions on ivory and bone of their principal and systematic procurement system. Small creatures weighing an average of 67 kg collectively conquered mammoths weighing up to six and possibly up to eight metric tons. Neanderthals and AMH thought enough of their accomplishments and cooperation with each other to memorialize their collective conquests of the biggest animals with pictographs of their killing zone, carcasses, homes, processing structures, pathways, vital rivers, bones, and tusks. The ivory process charts and Pavlov Map were definitely indicative of cooperation. The ivory Předmostí Riverine Hunting Map Process Chart was likely the symbol carried by the chief or leader of the killing zone, whose place is interpreted with a red star on the raft in the stream (Fig. 5A). The other identified process charts concerned the more mundane aspects of tissue processing.

The two ivory objects of note with artistic value are the Kyiv-Kirilovskaia Process Chart and the Pavlov Map (Fig. 4). The artistic value of ivory engravings suggests they may have been totems, tokens, or badges of authority for people who knew the routine acquisition and processing methods, did not need to refer to a chart, but provided necessary supervision and management of MMBS settlement operations. Some sub-systems, such as hunting, butchering, distribution of tissues, and processing may have required scheduling of work, a required regulatory mechanism in complex systems.

Sequential and onerous production activities, including management of a killing zone, required supervision. With a physical symbol, authority could be handed to another. In this way, someone was always in charge, work shifts and scheduling enabled, coordination achieved and work better focused.

5.0 Molodova I-Layer 4 Scapula Process Chart (Mousterian Neanderthal). Ukrainian Professor Oleksander Chernysh (1918-1993) drew a picture of incisions or carvings on a mammoth-bone scapula from Molodova I-Layer 4, which Middle Paleolithic site he excavated. (Nowell & d'Errico, 2007: Fig. 17(b)) @

https://eclass.uoa.gr/modules/document/file.php/ARCH164/The_Art_of_Taphonomy_and_the_Taphonomy_o.pdf). The Chernysh Drawing, photograph 2007 Fig. 17(b), is presented at a 45º angle to the perspective intended by the artist, with the river in a horizontal position. The photograph should rotate about 45º to the right and downward to make the river horizontal. A competing drawing is displayed on an Encyclopedia of Ukraine (E. of U.) website. (https://www.encyclopediaofukraine.com/picturedisplay.asp?linkpath=pic%5). Under both drawings and a photograph of the scapula, the parallel lines depicting the river take up the longest usable surface of the scapula (2007 Fig. 17 (a & b; E. of U. Drawing).

Chernysh's Drawing bears multiple similarities to the ivory process chart drawings under discussion: two long parallel lines indicating a river; superimposed foot-step marks (to the right, across the river); and what are perhaps lines and stakes depicted generally for securing mammoths in the docked position. By consulting both drawings, and merging recognizable elements, the overall pictograph shows the left-side head outlines of four (4) different standing mammoths, in profile (unless a sequence of actions regarding one mammoth was intended). The mammoths are all standing upright relative to the riverbank and river. When the drawings are viewed in the river-horizontal position, the four (4) mammoths depicted are aligned in parallel fashion along an almost straight line or axis from the upper left straight through to the Small Bottom Right Mammoth. The mammoths on each end of this axis are much smaller and do not include the mammoth bodies. In descending order, the mammoths depicted are as follows:

(1) *Tiny Top Left Mammoth*. This depiction at the left upper edge of the scapula drawing appears at the left end of a more prominent jagged line with two "mountain peaks" to the right. It shows the tiny profile of a mammoth, an eye, a descending trunk, and some small tusks protruding forward. This mammoth is only visible in the Encyclopedia of Ukraine Drawing.

(https://www.encyclopediaofukraine.com/picturedisplay.asp?linkpath=pic%5).

(2) *Large Upper Left Mammoth*. The outline of a mammoth with an eye and an upturned ear flap is depicted as if partly on the riverbank. The trunk is not depicted and cuts off at the edge of the river. This mammoth is only visible in the Chernysh Drawing.

(3) *Whole Large Mammoth Fully in River.* The Large Mammoth Fully in River has a misplaced mammoth eye, perhaps due to spalling in the correct position. A connection, dock, or walkway is depicted between the river shore and the Whole Large Mammoth Fully in River being butchered *or else* this is a large flap of thick mammoth hide (with subcutaneous fat possibly attached as in the Eliseevichi Process Chart) secured on the shore to permit access to the central body cavity of the middle mammoth *or* the flap served also as a walkway, *and this feature has a large arrow pointing to it,* probably added by Chernysh. This outline of the proposed walkway and/or hide flap is the main object clearly common to both of the drawings under study. Large Mammoth Fully in River is only visible in the Chernysh Drawing and faintly in the photograph of the scapula bone (2007 Fig. 17a), detectable as if the spalling void cut off the crown of the mammoth's head and in the approximate location Chernysh drew it. The photographs of the scapula by Nowell & d'Errico (2007) are good quality photographs, and they publish the technical characteristics of their photography, yet drawings are still the best modern depictions of the process charts under discussion.

(4) *Small Bottom Right Mammoth*. A small mammoth is depicted at the bottom, below the Whole Large Mammoth Fully in River and to the right, and only depicted by the head profile, a long trunk depicted as a single slightly curved line, an eye, and perhaps an ear flap. The top of this small mammoth's

head is formed in part by the bottom of the triangular base of the prominent arrow pointing to the flap of hide and/or walkway to the mammoth. This mammoth is only visible in the Chernysh Drawing.

Perpendicular to the prominent line terminating in the spalling void, we may see likely depictions of five (5) long and three (3) short mammoth ribs (Nowell & d'Errico, 2007: Fig. 17(b) @ https://eclass.uoa.gr/modules/document/file.php/ARCH164/The_Art_of_Taphonomy_and_the_Taphonomy_o.pdf). Coincidentally, Nowell & d'Errico (2007) studied a group of eight ribs.

The Molodova scapula might be the oldest document in the world, created about 26,000 years before the three Mezinian ivory process charts (Nowell & d'Errico, 2007). Nowell & d'Errico (2007) deny "Neandertals engaged in symbolic behavior" at Molodova I-Layer 4, but what is probably their own drawing posted on the E. of U. website contains the small symbolic representation of a mammoth.

Questions arose concerning excavator-caused knife marks and the accuracy of Chernysh's depiction (Nowell & d'Errico, 2007). Professor Chernysh and the other drawer observing the actual scapula had a very difficult, worn and obscure surface from which to make their drawings. (Nowell & d'Errico, 2007: Fig. 17(a & c). The drawing on the E. of U. website does not depict the same features as the Chernysh Drawing (https://www.encyclopediaofukraine.com/picturedisplay.asp?linkpath=pic%5), does not form a coherent pictograph, and only portrays the river, Tiny Top Left Mammoth, and the walkway or hide flap. The Chernysh Drawing is far more reliable than the competing drawing on the E. of U. website. Nowell & d'Errico (2007) mention "their drawing" but do not put it in their paper visually or with a reference, and for which the E. of U. website provides no source or author.

Mousterian Neanderthal symbolling appears or is suggested in the scapula process chart for the above and following reasons:

(a) The head outline, trunk, sloping back, and legs of the Whole Large Mammoth Fully in River in 2007 Fig. 17a, *very faintly* appear in an enlarged photograph of the scapula (2007 Fig. 17a).

(b) The left side profiles of four mammoths are portrayed standing up relative to the river, with heads aligned parallel to each other and along a straight line or axis.

(c) Neither artist drawing anticipated the RP, but Chernysh depicted it, and the other artist depicted the Tiny Top Left Mammoth on the same axis as the other mammoths depicted in the Chernysh Drawing.

(d) MMBS are distinctive markers for the RP and for the presence of process charts. The Molodova I-Layer 4 Scapula Process Chart comes from or near the Middle Paleolithic Mousterian Neanderthal MMBS, which is the only Neanderthal MMBS with thick walls yet found, which means the mammoths arrived via river, consistent with the Chernysh Drawing and RP.

(e) Neither the young farmer excavators using large knives nor any excavator or archaeologist implicated in recent modifications with metal tools would have had the knowledge or foresight to make something conforming to a MMBS settlement process chart. It is possible existing lines were made more prominent with metal tools, but the very many faint lines were not gone over with a knife.

(f) With one exception, not the scapula, Nowell & d'Errico (2007) in their *preliminary study* state "all of the markings are of recent origin." But about the scapula they state: "A few groups of parallel lines have the same patina as the bone surface and may be old. (Nowell & d'Errico, 2007). They do not publish their own scapula drawing (which the author assumes is the one posted on the E. of U. website), both competing drawings depict the river, at least one mammoth, and the possible walkway or hide flap. The Scapula Process Chart is consistent with a mega-site taking 15 mammoths. In no way can all of the many

faint lines have been gone over with a knife or made to appear like the ivory process charts. Chernysh had more time to devote to his drawing, and it is clearly done with better precision.

(g) That Chernysh thought a deer was depicted, and that the lines he claims were not found by Nowell & d'Errico (2007), actually reduces confirmation bias as Chernysh actually drew what appears to be a process chart. Given much obscurity, the interpreter of the Scapula Process Chart must guard against pareidolia. Further information may be obtained from Chernysh (1975, 1982 & 1983), who published in Russian or Ukrainian.

6.0 Předmostí Riverine Hunting Map Process Chart ("Předmostí Chart") (Gravettian/Pavlovian).

6.1 *Prime location*. In the Gravettian Pavlovian Culture in Moravia (31,000–29,000 cal BP) (Fewlass, et al., 2019; Svoboda, 2013), including the major site of Předmostí, "Hunting of animals was so successful that it did not have to be the only activity for all people at the time." (Musil, 2020). Předmostí was well-situated for mammoth hunting at the western end of the Moravian Gate, as the Bečva River transitions from a highland semi-mountainous stream to a meandering river at about Předmostí. (https://mapy.com/en/turisticka?source=area&id=26406&x). Předmostí I, II, and III took a total of over 1,000 mammoths (Musil, 2010). This is a record number of individual mammoths, but the bones were destroyed when retreating German troops burned Mikulov Castle in April 1945.

Three hunting dog skulls were found at Předmostí (Germonpré et al., 2012), and a "strikingly low number of carnivore species." (Musil, 2010). This pattern may indicate that dogs were employed not only in hunting mammoths but also in eliminating predators.

The Předmostí climate vacillated, included warm intervals, and likely drove out mammoth herds and hunters with the onset of the Last Glacial Maximum. (Musil, 2010). The Bečva River today is about 35 m wide with an average depth of 0.85 m but is prone to flooding and rises some meters with floods due to terrain and high runoff. (Julínek et al., 2025). Předmostí II sits on the highest terrain, Předmostí III lies at the lowest elevation, and Předmostí I is between the other two sites (Svoboda, 2013).

Předmostí has been studied for about 145 years, but not with the best record-keeping. Even though Předmostí was occupied for longer than other MMBS sites, their record number of mammoth kills and the cunning design of their killing zone allows us to regard their hunting scheme and structures (Fig. 5) as the epitome of successful mammoth hunting. Předmostí hunters committed their killing zone to ivory, and it also made its way into the Venus of Předmostí. (Fig. 5B). Svoboda (2017) displays a photograph of this engraved ivory from Předmostí I (Svoboda, 2017: Fig. 5), and a drawing of this Předmostí I tusk engraving (Svoboda, 2017: Fig. 6, top), the Předmostí Chart (Fig. 5). As with the other engravings, more information is gained from the drawing (Fig. 5) than the actual object. Figures 5, 5A, and 5B all provide the bird's-eye view, generally the most information-rich view of rivers.

The Předmostí Chart contains no mammoth, slope, or steps, but it confirms the hunting activities that occurred upstream of settlements and emphasizes the importance of constructed killing zones and massive thrusting spears. It is the only drawing yet found that depicts the killing zone with barriers, obstructions, snags, underwater impalement, channel narrowing, hunting stands, spearing positions, and traps. Although it is the only such map in existence, the output of Předmostí justifies treating this as a representative advanced exemplar.

The Předmostí Chart demonstrates why Předmostí was successful. We justifiably impute skill and lethality to the construction of this thrusting-spear killing zone based on the record number of mammoths procured at Předmostí. This zone enhanced the most powerful Paleolithic weapon.

6.2 *Animal Trap*. The Killing Zone at Předmostí on the Bečva River shared features with other types of animal traps. It was in essence a funnel trap, making it easy to enter and swim to, but difficult or impossible to escape, and lethal at the dead-end. Ravines on the way to the killing zone were likely blocked physically or by humans and dogs. Many devices and activities might have blocked egress from the river. Hunters and their dogs may have concealed their presence to surprise the mammoths at a paleo-ford, or they might have used drums, shouts, dogs, or fire to drive mammoths into the river from one side, with hunters on the opposite side of the river to block egress and perhaps fire projectile weapons. The use of bait cannot be excluded. In the killing zone itself, trees, logs and/or brush lined the river edges, blocking egress and probably providing the most distal adjustable support for massive spears. Small lines in-line with the streamflow are interpreted as impaling broken mammoth bones, probably well secured under or above the waterline. The raft is protected by those four (4) impalement structures, and the killing zone leader it is suggested may have had a regular hand-held thrusting spear, a position of honor carrying the last residual danger. The four impalement structures blocked the main channel and provided the “dead end” in addition to the other weapons, points, spears, and barriers. Elephants avoid quagmires and quicksand (Lyell, 1924), but this trap was worse and unexpected.

Hunters may have cleared obstructions from upstream and downstream kilometers to make it easier for mammoths to swim or float into and out of the killing zone, just as they may have blocked upstream ravines out of which mammoths could leave the river. A number of the MMBS settlements included hills or cliffs on one side, perhaps to restrict exit from rivers and to achieve the topographic narrowing of river channels.

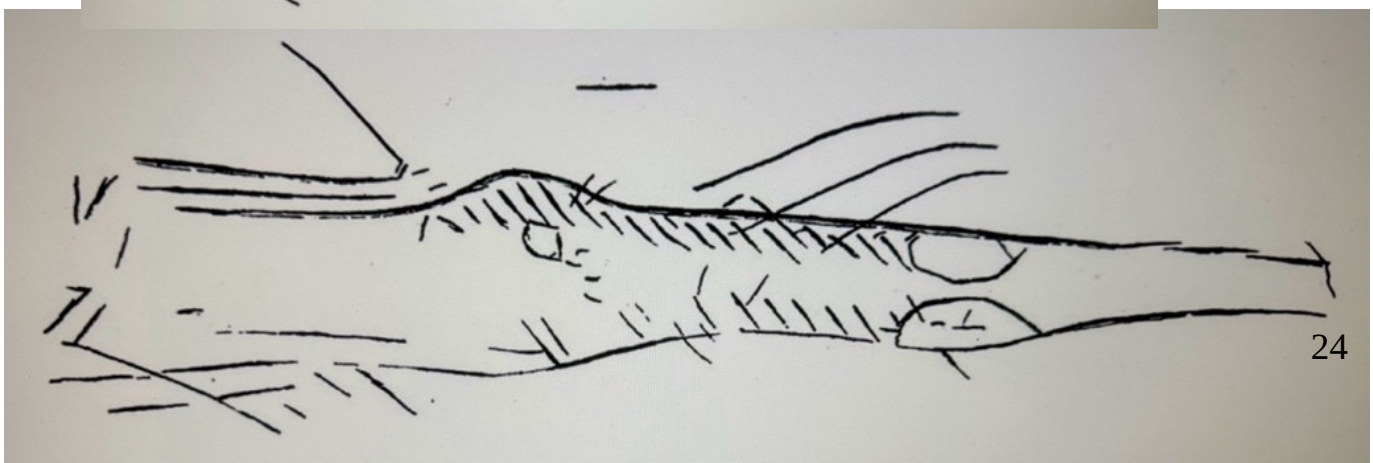

Figure 5: Drawing of

Předmostí Riverine Hunting Map Process Chart ("Předmostí Chart") *from* Svoboda, 2017: Fig. 6 (top) © University of the Basque Country (UPV/EHU) Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) license. Drawing presented by Svoboda without attribution.

The Předmostí killing zone demonstrates by its architecture why mammoths had difficulty swimming, floating, or walking through this killing zone without serious injury or death. Proboscideans generally were tough to kill in a short amount of time. The killing zone appears designed to keep mammoths in a vulnerable mid-stream position, away from the riverbanks, away from their herd, close to several positioned hunters, and within range of pre-positioned massive thrusting spears. The main job of hunting dogs may have been to force and then keep mammoths in the main river, mark their progress downstream, and announce the arrival of mammoths to the killing zone in faster floodwaters.

Svoboda came somewhat close to the mark regarding the Předmostí Chart, although he thought in terms of terrestrial acquisition. (Svoboda, 2017). Svoboda equates this drawing with some type of hunting strategy map of the valley for terrestrial acquisition drives. If we instead view this map from the riverine hunting perspective, it looks like a map of a narrowed and armed river channel, with a killing zone to take mammoths in the Bečva River. Half a dozen constrictions narrowed the channel for the better aim of pre-positioned massive thrusting spears and close shots or thrusts at mammoths. Overall, the killing zone contained and restrained the mammoth in all four cardinal directions: the downstream movement of water prevented travel upstream, barriers and impalement limited downstream movement, and both sides of the river were blocked with downed trees, branches, dogs, hunters with spears, atlatls, javelins, and maybe sharpened long bones. Mammoths, especially smaller ones, may have had trouble escaping flooding rivers.

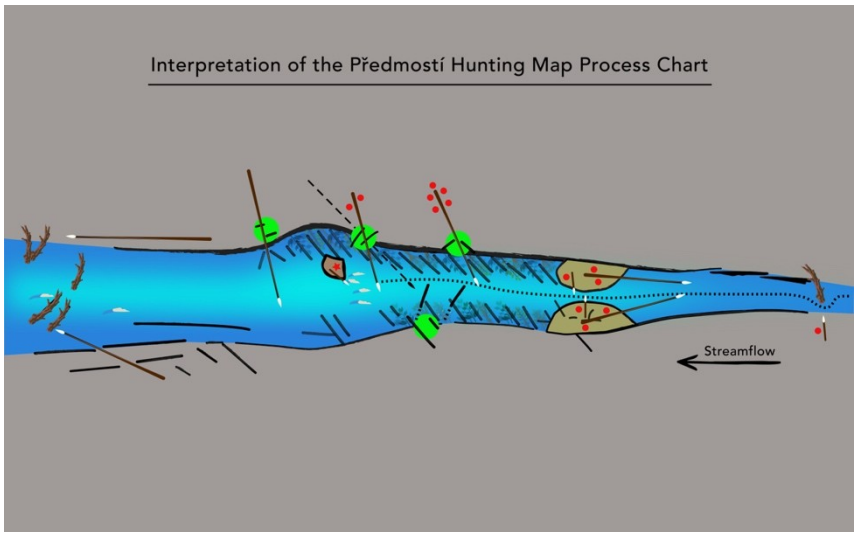

Figure 5A: **Interpreted Předmostí Riverine Hunting Map Process Chart (Killing Zone)** (**Předmostí Chart**)
Interpretive Diagram by Paz Fernandez (youandme@pazarts.com/www.pazarts.com)
Image © John Dewar Gleissner

6.3 Massive Lubricated Pre-Positioned Hafted Composite Thrusting Spears

6.3.1 **Primary Weapons of the Killing Zone**. Pre-positioned massive thrusting spears are interpreted here as the primary weapons of the killing zone. They reduced the risks associated with entering frigid water (hypothermia), eliminated exposure to mammoth counterattack and blunt force trauma by the trunk or tusks, and as a force multiplier enabled the combined strength of multiple hunters to be concentrated through a single weapon, thrust downward at an angle along lubricated cradles, chutes, or other support structures.

In mechanical and machine design, form follows function. The requirements of the work—reliably and promptly killing woolly mammoths—directly dictates the simplest physical shape and structure of the massive spear. Massive lubricated pre-positioned hafted composite thrusting spears could perform the work of reliably and promptly killing woolly mammoths, while hand-held spears, darts from atlatls, bows and arrows, clubs, and lithic knives could not. Because hand-held weapons could not perform the job reliably and safely, scientists never heretofore specified exactly how mammoths were killed.

The Paleolithic thrusting spear was far more powerful in terms of kinetic energy and killing power than throwing spears (javelins), atlatls, clubs, or bows and arrows. (Coppe, 2018). Part of the mass of the thruster, through pushing motion of the legs, contributed to total kinetic energy. (Coppe, 2018). Additional thrusting hunters on the same long spear increased kinetic energy. Thrusting spears retain force, gain momentum, and achieve greater penetration after initial contact. Once projectiles are launched, their energy starts to decline and cannot be sustained or increased. The most successful mammoth hunters maximized the effectiveness of the most forceful Paleolithic weapon by making the thrusting spear larger, longer, more accurate, more powerful, gravity-assisted through angled projection, almost certainly lubricated, *and safer*. By bringing the moving target into a narrow target area, the accuracy of pre-positioned spears was increased. For sedentary mammoth hunters, the evolution of massive lubricated pre-positioned hafted composite thrusting spears was far more beneficial than development of complex atlatls, darts, bows, clubs, and bows & arrows. (Coppe, 2018).

Historical long spears or pikes, not exceeding 6.5–7 m in length, including the Macedonian *sarissa* and the Japanese *yari*, required portability by individuals. These weapons relied on single soldiers, physical supports, leverage, and specialized handling techniques. The much larger Paleolithic thrusting spears proposed here, unconstrained by portability requirements, would have required lubricated and pre-positioned support and guidance structures. Pre-positioning is implied and was required by the weight, size, and difficulties in movement of the massive thrusting spears, the speed of floating mammoths, and the need for the supports interpreted from the Predmosti Chart (Fig. 5 & Fig. 5A). The copious amounts of rendered fat possessed by all organized mammoth hunters was readily available and applied to cradled spears or spear-chutes as lubrication to facilitate movement of the heavy spear.

6.3.2 **Assumed Operational Sequence in Construction of Massive Spears**. A straight pine tree approximately 12 m high could reasonably have been fashioned into a spear 10–11 meters long. Larger and sturdier trees of the same species used for ordinary spears could have been selected for their construction. Available stone hand-axes could chop down pine trees. After the removal of branches and bark with stone tools, the distal top end of the trunk in this example would have been approximately 5 cm in diameter, providing a suitable location for attachment of a sharpened tusk-ivory spear point. The basal end would have remained substantially larger, perhaps approximately 35 cm in diameter, although this diameter could be reduced with stone tools if desirable. The resulting spear would therefore have been considerably

heavier toward the rear than toward the point. The example given may be too short, because the spears depicted in Fig. 5 would stretch easily across the entire Bečva River segment shown. The required materials—pine trees, stone axes, mammoth fat for lubrication, ivory spear points, hafting material, and potentially ivory components for low-friction contact wear surfaces—were available in the environment. The precise construction and mechanical performance of such a system remain hypothetical because no complete spear-chute or comparable mechanism has been identified archaeologically or built by scientists. But the laws of physics and materials show these massive spears would effectively kill mammoths. The massive lubricated pre-positioned hafted composite thrusting spear was merely a larger version of the hand-held Paleolithic thrusting spear. Spear technology in Europe was well over 100,000 years old when Předmostí hunters developed their massive thrusting spears. The real complexity was in the support mechanisms and especially the sophisticated trap, the entire killing zone.

Curvature of massive thrusting spears shown in Fig. 5. The mammoth hunters probably manufactured these weapons from spruce, pine, or other straight-trunked trees. Bark may have been removed from the forward section while retained on the rear portion, causing the back half of the shaft to curve during drying. Such warping is well documented in wooden poles and timbers (Wengert, 2018). Warping is thought intentional, because all three massive thrusting spears, not pre-positioned in the chart, depicted in a parallel row, had about the same curvature on the back half (Fig. 5).

Polish & Lubrication. The shafts and support fixtures or cradles were probably smoothed, sanded with real sand, polished, and lubricated to reduce friction. Smooth wood on the spear and fulcrums, troughs, or supports, lubricated with animal fat, would lessen the coefficient of friction below that of raw wood against raw wood. Suitable support devices could have included forked branches, polished wooden cradles or troughs, reindeer antlers, drilled staves of wood, bone, antler, or ivory, old tree trunks or naturally occurring openings in mammoth skeletal elements such as vertebral foramina, acetabula, mandibles, or pelvic girdles, all requiring achievable modification (see Pidoplichko & Allsworth-Jones, 1998: 206, Pl. 46).

Mammoth hunters had ready access to large quantities of rendered fat and ivory, making lubrication between spear and ivory support structures readily available. Under a maximal engineering interpretation, the contact surfaces between spear and cradles at the most advanced sites may have incorporated inlaid polished ivory surfaces, ivory spear surfaces inside an ivory channel, potentially fashioned from matching concentric sections of a single tusk and lubricated with animal fat or grease. (see Pfeifer, 2019: Fig. 2c – concentric fracture of tusk). Perhaps just the support surfaces or maybe just the contacting spear surfaces contained polished and lubricated inlaid ivory. Such lubricated ivory contact surfaces would have brought friction closer to zero.

Ivory Spear Points. Impalement and spearing above or below water was most effective with the materials, dimensions, shape, securement, weapons, points, and locations chosen by experienced mammoth hunters, who had many options. They usually chose ivory spearpoints due to the superior physical characteristics of Paleolithic ivory (Pfeifer et al., 2019). Ivory could have been made sharper, smoother, more polished, and stronger than bone, and was the preferred projectile tip in the Eurasian Upper Paleolithic (Pfeifer et al., 2019). Sturdy and long recyclable ivory spear tips like those found at Pavlov I, Předmostí, and Dolní Věstonice are very good candidates for the spear tips used by most riverine

mammoth hunters. (Borgia, 2019b). The curvature of ivory spear points may have been preferred to better catch and penetrate the moving targets from an angle without fracturing.

Ivory spearpoints of all descriptions and types could withstand the higher forces generated with massive lubricated pre-positioned hafted composite thrusting spears. Sites associated with numerous ivory spear points, ivory link-shafts, and ivory basal segments include Pavlov I, Yana Rhinoceros Horn Site/RHS (Siberian Arctic), Sunghir, Milovice, Kraków Spadzista, Kostenki-Avdeevo Complex, Khotylevo 2; all sites with MNI data high enough to presume riverine procurement.

Ivory technology advanced to a very sophisticated level before and after the LGM. (Pitulko, 2915). Mammoth hunters learned to straighten curved ivory. It is unlikely heavy-duty ivory spear points and shafts were manufactured to make ever better hand-held thrusting spears, javelins, or atlatls. More likely, the technologies rose together, and heavy-duty sagaies were sought for the more powerful massive lubricated pre-positioned hafted composite thrusting spears and the tremendous forces caused by ivory being thrust into mammoths moving steadily downstream.

The composite and beveled ivory spear points were likely manufactured that way due to the substantial possibilities that both a rib and spear point would fracture at the forces obtained with massive spears when hitting ribs or other bones. The ivory spear points could, as Dr. Valentina Borgia suggests, be recycled (Borgia, 2019b) and would likely be found in the carcass floated to the settlements or the river segment flowing through the kill zone. Without beveling, the entire solid ivory spear point of some 20–30 cm (Borgia, 2019b) might have been ruined. With multiple spears in operation, some were bound to enter smoothly even if one or two hit ribs or other bones.

The best analysis of a great collection of ivory spearpoints, 45, those from Pavlov I, found fracture cracks at the tip of one spearpoint and intentional fractures to create the *biseaux*, a type of bevel (Borgia, 2019b). Dr. Borgia found the ivory spearpoints were composed of (1) pointed elements, the spear-tip, (2) link-shafts, and (3) basal elements, linked together with bevels or two *biseaux* by two different techniques. After her expert analysis and excellent photographs, Borgia states: “However, at the moment we are unable to state whether Pavlov's ivory points were used with hand-delivered spears or thrown using a spear-thrower.” The ivory points were not perfectly suited for either atlatls or hand-delivered spears. Pavlov I is only 75 km from Předmostí, where evidence of massive spears was found in an ivory carving or incision, an ivory depiction that was only cleaned in 1990. The answer to the binary indecision of Dr. Borgia is a third type of weapon, the massive lubricated pre-positioned hafted composite thrusting spear supported by spear-chutes. The reason for beveling is to withstand powerful kinetic energy and through shock absorption, prevent wooden shafts splitting, stop damage to ivory at the hafting joint, and permit interchangeable parts. (Borgia, 2019b). At sites with indeterminate use of ivory spears, shafts, and points, especially when beveling is found, the use of massive lubricated pre-positioned hafted composite thrusting spear supported by spear-chutes might be inferred.

Lithic spear tips may have been used to create a larger inner wound cavity. (Wilkins et al., 2014). Mammoth hunters may have used a variety of spearpoints, lithic, ivory, and bone, some perhaps designed for certain parts of the mammoth or spear stations within the killing zone. Any impact would be greater if the spears were pointed upstream to some extent at the time of initial impact with a substantial river current.

6.3.3 **Supporting Surfaces and Guides for Massive Spears** ("Spear Chute"). A spear of this size and weight would have required physical support (and at the end perhaps including human muscular support) at two or three locations along its length. The proposed supports may have consisted of lubricated wooden channels, cradles, forks, bone surfaces, bone foramens, ivory surfaces, ivory bracelets, simple rests, lubricated material of any kind, or other low-friction surfaces of varying lengths. Because the archaeological literature and evidence does not establish a specific design or name, the supporting mechanism can be referred to provisionally as a "spear-chute." Construction of supports likely had different designs or dimensions according to the portion of the spear it supported. Design probably varied according to the local conditions, materials, terrain, proximity to the river, and configuration of individual killing zones. The term "spear-chute" is therefore used as a general designation rather than as a claim that a standardized Paleolithic device existed. Other terms include support structure, support surface, cradle, guide, track, channel, gravity-fed ramp, fulcrum, distal support, riverside support, thrusting-spear support, V-shaped support, forked branch, support branch, vertical support, and lubricated cradle.

The proposed system therefore differs fundamentally from hand-held spears, javelins, clubs, arrows, and atlatl darts. Its potential advantage was not simply the length of the spear, but the combination of greater mass, multiple operators, mechanical support, reduced friction, sustained force application, and pre-determined directions so that immediate aiming was not required.

6.3 **Progression of Mammoths Through the Killing Zone**. Mammoths entering the killing zone from the right side of the Chart and moving downstream toward the left encountered a series of structures shown in Figure 5 and interpreted in Figure 5A:

6.3.1 *Initial Barrier and Attack Position.* At the far right of the chart, a tree or barrier obstructs slightly more than half of the river channel, forcing mammoths toward an open passage. This configuration placed one or more hunters in close proximity to animals moving downstream. Hunters positioned on the bank nearest the open channel would have occupied the most advantageous locations for spear attacks. Unless atlatl darts were launched upstream, this may have been the location of the initial assault. The channel upstream of the twin ovals appears deeper and narrower, while downstream it gradually widens and becomes more shallow, consistent with hydraulic principles and the proportions depicted in the chart.

6.3.2 *Twin Oval (or Semi-Circular) Platforms*. The size and placement of the twin oval platforms, together with the narrowed channel, suggest that they served as major attack stations. Each platform may have accommodated multiple hunters and weapons. Shorter spears are depicted as being wielded by individual hunters. Possible methods of attack include downward or horizontal spear thrusts, massive thrusting spears directed upstream or downstream, axes or chisel-shaped hammers, and weighted harpoons or drop-spears. If attached to the trunk, a weighted weapon may have hindered movement or contributed to drowning, as suggested for large game hunting elsewhere (Agam & Barkai, 2018). Mammoths may have been struck in the neck, throat, trunk, eyes, ears, or other vulnerable areas before, during, or after passing between the twin ovals. On the lower platform, one Y-shaped support fork is interpreted and illustrated as supports for spears. The well-placed platforms conceivably allowed hunters to swing a chisel-like stone weapon on the joint between the head and neck where mahouts drove chisels to kill their berserk war elephants.

6.3.3 *Water Levels and Hydraulic Conditions.* If water levels in the Bečva River were low, the channel would have been narrower and shallower, and the impalement bones would more likely have been

above water. As the river widened, water depth would generally have decreased, potentially exposing portions of mammoths to attacks by atlatls or javelins. Mammoths may also have encountered submerged spikes or other obstacles. The velocity, discharge, and depth of the river during hunting episodes are unknown. Mammoths could remain buoyant while partially submerged with bent legs, and a strong current would have carried them downstream at considerable speed. Variations in river width and depth may help explain the apparent need for exceptionally long spears.

6.3.4 *Barrier Systems.* With the river flowing from right to left, approximately twenty-one oblique lines on the upper bank are interpreted as downed or sharpened Scots Pine trees positioned at roughly 45° angles to the current. Their submerged tops and branches may have restricted movement toward the shoreline. Given the force of the current, these barriers need not have been massive or super-strong to be effective, but may have included sharpened saplings, various trees, stakes, etc. Similar features, numbering approximately ten to twelve, appear along the lower bank and point downstream at comparable angles, further restricting lateral movement and channeling mammoths toward the intended route.

6.3.5 *Constricted Channel.* Two trees on the lower bank possess extensions that project farther into the channel, one at nearly a 45° upstream angle. Together, these features further constricted the river and directed movement toward a narrow passage adjacent to the upper bank. This concentration of movement would have brought mammoths within range of hunters using large thrusting spears from shore, especially from the shore depicted as above the river. The constrictions nevertheless left a navigable channel leading directly toward the raft and the four impalement bones shown to the right of the raft. If these extensions represent the tops of long trees or stacked smaller trees, they may also have served as distal supports for pre-positioned massive thrusting spears.

6.3.6 *Spears Depicted in Fig. 5.* Three long, partially curved lines on the upper bank of the Předmostí Chart (Fig. 5)—one entirely on land and two primarily on land—are interpreted as loose massive thrusting spears, not pre-positioned for use, either stored or graphically represented as on higher ground. Additional long lines, some straighter and possibly representing similar weapons, appear on the lower bank, in the lower-left corner of the chart, parallel to the upper bank, and in the upper-left area where two examples may be depicted with small handle-like features (Fig. 5). The evidence and need for lethality suggests that pre-positioned massive thrusting spears operated from both sides of the river. These weapons may have been powered by teams of one to ten hunters per spear, generating substantially greater thrusting force, penetration, lethality, and control if multiple hunters applied thrusting force.

Several features of this system could have increased the force delivered to the target relative to that of conventional hand-held weapons. These include the substantially greater mass of the spear, the application of force by multiple hunters, the use of supporting surfaces to permit a coordinated thrust, the downward inclination of the spear, and the possibility of continued thrusting after initial penetration. A polished and fat-lubricated shaft would also have reduced friction between the spear and its supporting surfaces, potentially allowing a greater proportion of the hunters' applied force to be transmitted to the spear.

6.3.7 *Interpretation - Figure 5A.* In Figure 5A, these possible support elements are represented by such features as the green-circled support fulcrum, Y-shaped support, simple V-shaped or forked-branch support, wood or ivory support surfaces, manual human support or guidance, and crossed branch or

trunk segments. These interpretations should be regarded as functional hypotheses rather than definitive identifications of individual archaeological features.

The interpretation of massive pre-positioned thrusting spears in Fig. 5A is based on: the massive straight and curved lines depicted prominently in the Předmostí Chart, the obvious lethality and effectiveness of pre-positioned massive thrusting spears used to take mammoths if thrust downward along lubricated chutes or cradles, the absence of any previous consensus about what weapons and techniques were used to take mammoths, size of spears commensurate with size of mammoths, refinement of existing Paleolithic technology, high MNI production at mega-sites, the detection and interpretation of support structures in the Předmostí Chart, the superior hunter safety provided by pre-positioned massive thrusting spears, and the architecture of the killing zone and riverine terrain both suggest use of massive thrusting spears. Also noteworthy are three sets of double lines forming a "V," roughly equivalent to the two upper (or lower) sides of an equilateral triangle. One is directly below the green circle of the left deployed spear. The second one is within the green circle of the right deployed spear and is considered a fulcrum in the listing of Green-circled Support Fulcrums above. The third one projects out from the left side of the lower oval platform, into the blue river, but without other marking. These arms may represent fulcrums, support structures, a simple "V" support or forked branch or made from two crossed segments of a branch or trunk, or distal supports for spears that could be operated at two different angles.

In Fig. 5A, potential and illustrative hunter positions are shown with dots and the leader's position with a star, to illustrate general or possible locations relative to massive and individual spears. The Interpretation did not attempt uniform or complete depictions of all spears or fulcrums. The killing zone in question may have held up to eight (8) massive or long spears and shorter or longer spears.

If the primary spear-chute was elevated, with the straight forward section of the spear descending at a steeper angle toward the river, a curved rear section would have kept the back portions of the spears within convenient reach of hunters standing on relatively level ground. A perfectly straight spear in the same angle of depression would place the rear portion uncomfortably high, reducing efficiency. Steeper angles of incline significantly increased the spear's kinetic energy and velocity, so mammoth hunters may have chosen timbers where the rear portion of the spear sloped down to pedestrian levels on ground. The bowed spears in Fig. 5 might have appeared straight from above as in Fig. 5A if the bowed portions stayed within one plane.

Because only the forward section needed to be straight, curvature in the rear portion could rotate upward, downward, or laterally if desired without significantly affecting performance. Spears on the top riverbank in Fig. 5 were shown deployed in Fig. 5A for two reasons: that side was closer to the intended mammoth route and the short, paired lines interpreted as primary fulcrums were clearer on that side; but spears on both sides are suggested in the Předmostí Chart (Fig. 5 & 5A) and would increase lethality.

6.3.8 *Proposed Operation of Spears.* The spear point could have been positioned approximately 1–2 m from the anticipated path of a mammoth floating downstream. A pre-positioned spear inclined at approximately 15° could then have been driven forward by several hunters applying force simultaneously from the rear. For more momentum, they could run the spear in more than 1-2 m.

The pre-positioned spears may have required movement of only one or two meters along a predetermined path. If thrust at an angle downward, supported by a lubricated fulcrum, chute, or cradles and a distal support resting on stacked logs, staves, or small tree trunks, a coordinated thrust could have

driven the weapon deeply into a mammoth. Between passing mammoths, some spears may also have shifted laterally on their fulcrums to permit attacks from different angles, as illustrated in the Interpretation. The chief or leader may have played a role in having individual spears thrust by all of their handlers at the same time.

It is difficult to imagine a better weapon to kill woolly mammoths than these thrusting spears. Their size was commensurate with the size of the prey and provided maximum power, penetration, lethality, reliability, and hunter safety. Higher angles of downward slope increased the gravity feed, improving the speed and power of the thrusting spear. Gravity adds to the thrusting force while lessening, along with lubrication, friction in the supporting surfaces.

Pre-positioned spears, narrowed river channels, and prepared support structures improved the spears' effectiveness. The constricted channel implies a need for long spears capable of extending beyond shoreline barriers, in Fig. 5A interpreted as stacked pine trees. Destruction of internal organs seems not to leave artifacts of note, because the earliest published direct evidence of mammoth hunting comes from poor point placement in lateral ribs and scapulae. (Wojtal, et al., 2019; Wojtal, et al., 2025; Nikolskiy & Pitulko, 2013).

The design of the killing zone provided a predictable target by channeling mammoths into a confined route and, potentially, by impaling or arresting their movement. Although a spear could strike bone and fail to penetrate optimally, the immense size of the target greatly increased the likelihood of a successful hit when the weapon was accurately timed and aimed toward the mammoth's anticipated position.

Pre-positioned massive thrusting spears could have been balanced on these fulcrums and distal supports, pre-positioned to strike an approaching mammoth. Teams of hunters could then have driven the weapon downward along the gravity-fed ramp and forward into the target without further aiming.

In the Interpretation (Fig. 5A), the spearing crew at one location might have then moved swiftly to the next downstream massive thrusting spear in time to spear the mammoth again. One deployed spear is shown unattended. Mammoth hunters likely preferred their spears to stay in the mammoths for maximized internal injuries. Some massive thrusting spears may have broken during use, especially if the spears were made of dry wood and struck ribs. In a pinch, they could use sharpened wood for their spear-tip. Depending upon the entry point, it was theoretically possible for one massive spearing to kill the mammoth, hold the mammoth in the speared position subject to hydraulic forces, collapse a lung, or injure the mammoth fatally, even if it took hours or even days to die on its long or short journey to the river dock below each settlement. A harpoon-type point might have been used to grab or hold internal tissues. A mammoth rib might have been fractured, breaking both rib and spear, and causing internal injuries to the mammoth. Mammoth hunters undoubtedly experimented, learned from others, and steadily improved their systems.

A key feature of these massive spears was that Předmostí hunters would have had safe places to stand while inserting, firing, shoving, or throwing spears (massive, longer, or shorter), javelins, atlatl darts, or arrows. Close contact with mammoths at Předmostí was eliminated by distance, length of spear, terrain, use of projectiles, and the helplessness of mammoths.

6.3.9 *Impalement Midstream.* A mammoth proceeding downriver floats or swims directly towards what looks like a raft. The four marks in line with streamflow are consistent with underwater or above-water structures for impalement, interpreted here as broken and sharpened long mammoth bones

emerging from the water. The river widens where the raft is located. The four impalement structures were installed directly across the mammoth's controlled route, the likely terminus for many Předmostí mammoths, before they reached the raft or could extricate themselves. For underwater or secured impalement, long fractured mammoth bones created sharp points and edges (Haynes, et al., 2021). Spiral/helical/curvilinear fractures to various mammoth bones or shards could probably have been sharpened further to make formidable underwater or above-water impaling weapons. (Haynes, et al., 2021: Fig. 5). Humans have knocked the ends (appendicular epiphyses) off long animal bones for millennia to create sharp shafts. (Blasco, et al., 2024). Svoboda et al. (2005) found no long bones or tusks at Milovice, where they might have been used for a killing zone. Waterproof osseus and ivory points, sharpened antlers, or embedded lithic knives or points, or sharp wood poles, may have been secured, hafted, inserted in or tied to wood, stuck in the streambed or between rocks, or otherwise secured to cut or puncture mammoths under or above water. (see photos, Reynolds, et al., 2019; Painter, 2004). Impalement probably varied by location, purpose, cost, availability, size of spear, delivery method, kinetic energy created, securement, and stage of killing. Points of all types could have confronted mammoths within the killing zone.

6.3.10 *Raft.* Impalement structures guarding the raft are assumed firmly affixed, although they might not have been firmly fixed, may have allowed some movement, and perhaps were connected to the raft. The raft may have held (a) the chief or leader, designated by a star in the Interpretation, with the best location and perspective down the river and of both sides, controlling killing zone activities, telling spearers when to elevate or depress spears before mammoths arrived, when to thrust as a group, etc. (b) hunter(s) with spears or javelins, perhaps aiming at specific parts of the mammoth head (trunk, eyes, ears, neck, trachea, skull, face, or mouth), or (c) hunter(s) and/or support devices or surfaces to help guide the pre-positioned massive thrusting spears to an impaled mammoth. One leader could perform all these functions.

6.3.11 *Last Barriers in Killing Zone*. Proceeding downriver from right to left in the Předmostí Chart (Fig. 5 & 5A), at the left end of the chart are some five barriers, shown as logs. Massive thrusting spears might have been employed at this late stage.

6.4 *Time of Death*. Mammoth hunters did not have to kill mammoths before they were floated down to the settlements. Mammoths escaping from this killing zone, if any, were easier prey or in the extended process of dying. Barely alive mammoths may have floated more reliably than carcasses of dead mammoths. Hunters may have had permanent barriers or catches at each settlement, disallowing any further downstream movement of mammoth carcasses or some way to attach a rope to the carcass.

The Předmostí Chart indicates it would have been possible for Neanderthals with only spears and obstructions to take mammoths, as they did at and during Molodova I-Layer 4. A channeling of mammoths to a predetermined location and massive aimed thrusting spears were sufficient even if not most efficient.

6.5 *Possible Restraints.* Ropes, nets, or branches might have kept mammoths in one place long enough to spear them. One strong rope made from leather, vines, or elephant hide might have snagged mammoth tusks, lassoed upraised trunks of submerged mammoths, or altered mammoth motion in a way sought by mammoth hunters. Conard & Rots (2024) demonstrated that an ivory piece with four modified holes could readily make rope out of cattails; but another use for that item could have been to attach it onto a log and let the sharpened point impale mammoths moving downstream.

6.6 *Hunting Strategy*. When other Paleolithic hunting weapons, hand-held thrusting spears, javelins, atlatls, clubs, and bows and arrows are compared to massive spears, the superior power, lethality, safety, and survival value of massive spears is clear. The lethality of smaller weapons increased with danger. To maximize the power of Paleolithic hand-held weapons, hunters had to get closer to wild mammoths. The entire *system* making up the River Paradigm shows mammoths were hunted. Maximum hunter safety and reliable lethality could only be achieved through massive spears used in riverine hunting, in pursuit of the simplest, most parsimonious, reliable, and productive hunting strategy: "Confine and kill while trapped and helpless in the river." Prepared rivers were the only way to both confine mammoths and kill them while they were helpless.

6.7 *Other considerations and unknowns*. Flooding rivers with high water speeds and increased depth exert enormous force on elephants, potentially forcing whole herds downstream. (Video). Spring or other flooding may or may not have been a favored Paleolithic hunting time, but the evidence suggests it swept mammoths downstream, kept them immersed, and aided impalement. Streamflow and perhaps the mammoth's physical struggle pushed the mammoth further onto the sharpened bone, wood, stone, or ivory impalement or spear. Impalement would injure and immobilize the mammoth for some period of time, presenting a stable target, and downstream movement of the mammoth would make the inserted spear wound more damaging. A sharp object sent into the mammoth's extremely sensitive tusk would drive it berserk or cause debilitating shock. Weapon use and tactics may have varied according to the height of the river, size of the mammoth, time requirements, number of mammoths, past experience, etc.

Mammoth hunters may have ringed some trees or saplings the year before they intended to cut them down. Cut dry wood could be floated to where it was needed. A stout, sharpened individual spear, gradually tapered with a sharp point, perhaps with grease on it, made of just wood or with ivory, bone, or lithic spearpoints, might have been effective at the shorter but safer distances allowed by riverine mammoth hunting at narrowed channel locations. (Wilkins et al., 2014). The weight and tensile strength of the spear would differ between dried versus green wood.

If multiple mammoths were killed on one day, any not immediately butchered could be stored safely in frigid river water. It may have taken hours or days to float the carcass to the settlement or wait for bodily gasses to float the mammoth. The Předmostí killing zone warrants the supposition that mammoth hunters spent much more time constructing killing zones and processing carcasses than in actual hunting of mammoths. Some bands may have built two or more of these killing zones at different river locations. Every MMBS settlement might have hunted differently.

6.8 **Schematic Venus of Předmostí**. These twin oval structures have been equated to breasts on the Venus of Předmostí (d'Errico et al., 2011; Svoboda, 2017). This connection corroborates the importance of this killing zone to Předmostí mammoth hunters. The two large ovals creating the narrow channel in the drawing, probably platforms, may have been the inspiration for the breasts in an unusual female depiction, "a woman composed of geometric shapes," the Schematic Venus of Předmostí (d'Errico et al., 2011; Svoboda, 2017). A double-meaning as suggested by Svoboda (2017) and/or Klima is likely, as both women and the Bečva River (or one of its tributaries) gave life. The triangular shape of the woman's head and constricted neck may represent the flow of water through the two constricting ovals, depicted as female breasts. The Předmostí Chart has been characterized as a feminine figure for multiple reasons (Svoboda, 2017). Male aspects of massive thrusting spears noted without comment.

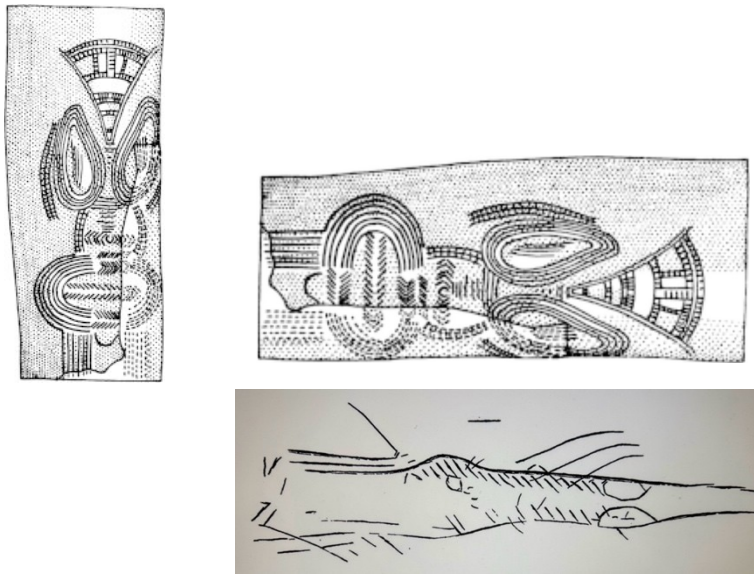

Figure 5B: **Two Views of The Venus of Předmostí** & **Comparison** (Hugo Obermaier, Public domain, via Wikimedia Commons) compared to **Figure 5**: Drawing of Předmostí Chart *from* Svoboda, 2017: Fig. 6 (top) © University of the Basque Country (UPV/EHU) Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International (CC BY-NC-ND 4.0) license. Drawing presented by Svoboda without attribution.

Through these process charts (also sometimes known as maps, plaques, or churingas) and possibly symbols of authority, we gain a deeper, more dynamic and fact-based understanding of the mammoth palaeoeconomy. Mammoth hunters centralized and standardized the entire process from founding the MMBS settlement on navigable rivers through systematic hunting, killing, transport, processing, storage, and consumption, aided by site and capital improvements. Each site operated in the same basic way based on all the efficiencies, terrain, and the mammoth-bone circles they left behind.

These ivories and scapula supply the behavioral and economic paradigm for the palaeoeconomy in Eastern and Central Europe, the essence of their productive culture. They are each a set of data points and archaeological facts, "an accurate observation that carries unambiguous information relative to human-hominid behavior." (Binford, 1981:18). The meaning of the process charts was identified on the internet, in published works on the internet, museum drawings, and in books by Pidoplichko/Allsworth Jones (1998), Soffer (1985), and others. Pidoplichko hypothetically interpreted the four huts in the Mezhyrich Map as four dwellings (Pidoplichko/Allsworth-Jones, 1998:155, Fig. 40), three of which he excavated, which is not contrary to their use as smokehouses or with the external hearths he found.

7.0 Unknowns, Uncertainties and Shortcomings in Scientific Literature and Artwork Concerning Terrestrial Procurement

Hominids have been hunting, butchering, scavenging, and consuming mega-faunal proboscideans for over a million years, since *Homo erectus* by some scholars, and with greater frequency and success

tracking human evolution (Haynes, 2022), but never before firearms with the repeated success demonstrated by Upper Paleolithic riverine hunters.

Scientific inquiry into large mammoth bone accumulations and the mammoth palaeoeconomy proceeded under several unknowns, questions, doubts, contradictions, and assumptions concerning terrain, weapons, hunting techniques, and procurement. In 2019, Dr. Valentina Borgia of the McDonald Institute for Archaeological Research at the University of Cambridge wrote: “In conclusion, despite the central role of hunting among Palaeolithic populations, we are still not close to correctly reconstructing the variety of weapons and hunting techniques they used.” (Borgia, 2019b). The River Paradigm goes a long way towards correctly reconstructing the main weapon and hunting techniques used to harvest and process woolly mammoths.

Riverine acquisition, transport, and butchery were not suspected as a pattern. Studies, articles, books, artwork, and discussion proceeded on the tacit or intentional assumption of terrestrial procurement and transport. A terrestrial or nomadic procurement system assumes hunting or scavenging on dry land or by nomadic hunters anywhere, killing of individual mammoths or whole herds on land, bone seeking and/or terrestrial bone collecting, terrestrial transportation or herding of mammoths, and terrestrial butchery of *Mammuthus primigenius*.

7.1 **Shortcomings of Terrestrial Procurement Theories**.

Large Terrestrial Hunting Territory Logistical Analysis: The following passage claims mammoth hunters had a huge hunting territory on land: “This I termed the ‘semi-[sedentary] strategy’ (Djindjian, 2009): a large territory of about 100 000 km^2, a settlement occupied for eight to ten months and used as a main dwelling, and movements dedicated to seasonal or specialized hunting and to raw material procurement.” (Iakovleva et al., 2012). As a circle, this territory had a radius of 178.4 km. Territory of this extent may be indicative of the seasonal *mammoth* range surrounding any settlement. But the logistic, labor, calorie expenditure, defense requirements, and travel difficulties for 67 kg *sedentary* mammoth hunters hunting this vast terrestrial territory are insurmountable. Only nomadic hunters could hunt over a terrestrial territory of 100,000 km^2. The RP permits hunting mammoths that roam over 100,000 km^2 or more territory, but procures them starting at optimal locations, such as paleo-fords across rivers.

The RP supposes these mammoth hunters were sedentary, which is now the consensus per Demay, et al. (2021a), even though they had warm-weather hunting camps upstream. The depiction of elevated meat/fat caches, the thick walls of MMBS, and elaborate killing zones are all strong indicators of sedentarism. Mammoth hunters spent their winters inside thick-walled MMBS. There are simply no significant bone accumulations associated with nomadic hunters comparable to those accumulations and MMBS created by sedentary hunters.

Foraging Radii Analysis. Given the small human foraging radii, finding or scavenging carcasses with meat would be virtually impossible within a 178.4 km radius circle. “[F]oraging radii were 2–3 km during the Early Holocene, whereas during the Middle Holocene these radii were 6–7 km...in a high elevation desert in NW Argentina.” (Pintar & Rodriguez, 2015). In the southern Sierra Nevada, Morgan (2008) found an extreme pre-historic human foraging limit of 9.4 km, with a caching limit for acorns of 5 km. Hunting radii might be longer, but with each lengthening of the terrestrial hunting radius, the transportation burden of mammoth tissues rose.

Killing a herd in situ. Mammoths were difficult or impossible to herd or bring into a narrow location, especially if they are driven towards a known human settlement. The mammoth bone accumulations are on the slopes of riverbank hills, mammoths had flat feet and, like modern elephants, mammoths disliked or avoided walking uphill unless natural steps were provided. (Riverbank slopes worked in favor of the RP.) Mammoths could not be "herded" up a slope. If they were herded into one place, it would be impossible to kill a whole herd at that spot without them running off or over the hunters after the first mammoth was attacked or threatened. Iakovleva et al. (2012) did not find that killing a herd *in situ* was demonstrated, an understatement.

Fast-access & late-access scavenging. The most advanced Paleolithic producers were characterized as nomadic scavengers: "We propose that resource-acquisition from dry found mammoth carcasses can be classified as a form of "gathering" and resource-harvesting from fresh found carcasses can be classified as 'scavenging.'" (Demay et al., 2021b). Gathering and scavenging from dry-found or fresh-found carcasses would have been very rare given the limited foraging radii and paltry resources obtained compared to the value of one whole fresh mammoth carcass delivered by river to the MMBS settlement. Mammoth people who lived in MMBS did not likely waste their time scavenging or gathering mammoth bones, because they had to spend enormous amounts of time processing 100% of each mammoth delivered whole to their docks, which included vitamin-rich viscera and organs. (Guil-Guerrero, 2023). The RP literally delivered resources. Mega-sites generally had more bones in their bone beds than could be readily used.

To explain the smooth condition of bones in a scavenging mode of acquisition, the concept of "fast-access scavenging" was invented, meaning that humans arrived at the carcass and bones before scavengers and predators. Also envisioned was "late access scavenging, i.e. after predators have taken the best parts." (Pean & Patou-Mathis, 2003). Millions of years of both scavenger and human evolution refute the theories of Upper Paleolithic fast-access and late-access scavenging. The real scavengers (also predators), wolves, wolverines, lions, cave hyenas, brown bears, arctic fox, buzzards, crows, hawks, eagles, flies, insects, etc., evolved over millions of years to have senses of smell or eyesight many times greater than the noses and eyesight of humans, and the ability to move about on the air or on four legs much faster than humans. Some scavengers ran in packs, and some searched for food at night. Slow bi-pedal humans with relatively poor olfactory abilities, who did not often venture out at night, could not out-race real scavengers by "fast-access scavenging," nor would much edible tissue be found after "late-access scavenging." Human mammoth scavengers would have to avoid carcass fights and attacks by predators during transit. In no way could humans win the access race every time with the great majority of bones showing no carnivore activity. Bi-pedal scavengers with limited foraging radius arriving late to kills would have confronted wolves, brown bears, lions, hyenas, or wolverines, none of which would surrender a huge carcass without a fight.

Procurement near settlements very unlikely. Mammoths, like elephants, had one of the best senses of smell in the animal kingdom. Mammoths would avoid the constant smell, sound, and sight of humans and dogs at MMBS settlements, as modern hunters of large game verify. From MMBS, most of any foraging or scavenging radii would be useless because older and wiser hunted mammoths avoided the smell, sight, and sounds of humans and dogs. Finding, much less killing, a mammoth close to a settlement

on land would be almost impossible, refuting the existence of “kill sites” near MMBS. If mammoths were evenly distributed and taken within a hunting territory of 100,000 km^2, settlements could not take the numbers of mammoths shown harvested at mega-sites, and far less productive nomadic hunting would have been employed.

Inaccurate AMH Killing Mammoths on Even or Open Steppe Ground. Close-contact hunting is how mammoth hunting is usually portrayed in the popular press, and in some museums and books, but it takes little account of hunter safety, mammoth counter-attacks, atlatl use, domesticated hunting dogs, the time wounded mammoths took to die, the advantages of river terrain, processing costs, or the RP as reflected in the process charts. Few if any Paleolithic hunters could with one hand-held spear thrust penetrate to the mammoth’s vital organs. Death by blood loss or poison was a slow process. Hunting one mammoth from a matriarchal herd on steppe land would be too easily noticed by the herd and dangerous. Female mammoths, with a huge long-term genetic investment in each calf, aggressively defended their young (if they closely resembled elephants, which genetically, they did). (Tsavo Trust, 2026). Hunted elephants are more aggressive towards humans, kill and wound many humans in Africa and India, sometimes charge humans, remember past negative encounters with humans, and pass on their defensive and aggressive behaviors and attitudes from generation to generation. (Wakoli & Sitati, 2012; Tsavo Trust, 2026). This cognitive and behavioral memory may have caused mammoths to avoid some paleo-fords.

Charging mammoth impalement theory. The isolation of one specific terrestrial hunting technique, holding a spear and letting the charging mammoth impale itself on the spear, was too limited, not likely productive of many mammoths, posed catastrophic hazards, and probably injured or killed mammoth hunters foolish enough to attempt it. “As a rule elephants do not charge unless they are wounded.” (Lyell, 1924:39). Fighting on even ground was something for humans to avoid by killing mammoths in rivers. The proposed method by Byram et al. (2024) requires mammoths to ignore the sharp spear to their front, not dispose of it or hunter with a slap of their trunks or tusks, and it narrows many animal and human positions into one technique that required hunter and hunted to meet head-on and not vary their behaviors. (Cf. Byram et al., 2024). An elephant’s trunk contains over 40,000 muscles and a swing from the trunk delivers a blow equivalent to a heavy club, which could be followed by trampling of the prostrate hunter. In terrestrial hunting on even ground, the mass and energy of mammoths eliminated any margin for human error. Counting on charging woolly mammoths to impale themselves on spears held by human hunters the same way every time does not take account of the various positions the spear might enter or deflect from the mammoth body, the reliability of spear immobility, the prospect of mammoth flight, the questionable inducing of a mammoth charge, the possible reticence of younger mammoths to charge, the huge power imbalance, or the variable courage and spear designs of hunters. The best and most reliable illustrations of Paleolithic riverine and safe terrestrial hunting methods are far more complex and planned than one dramatic encounter on even ground.

Common Erroneous Depictions. A common depiction of AMH mammoth hunters shows them surrounding mammoths on open or even ground or very shallow water with large spears. No complete terrestrial procurement system has yet been reconstructed for sedentary mammoth hunters. Terrestrial theories of mammoth hunting fail feasibility analysis when considered as a system, cannot show provenance or provenience for bones taken terrestrially, and never congealed into a system moving

coherently from input to output. We can compare both Figure 5A – Interpreted Předmostí Chart (Fig. 5A) and Předmostí Chart (Fig. 5) with *any* of the common depictions of terrestrial mammoth hunting, nearly all of which surveyed contained inaccuracies. Inaccuracies and unrepresentative aspects of terrestrial hunting include mammoths raising up high on their hind legs, killing mammoths in pits that were not likely dug through permafrost, nearly naked Ice Age hunters, hunting mammoths on solid snow or ice, throwing rocks down from high cliffs, Neanderthals and AMH merely observing mammoths from some distance, hunters expressing fear of mammoths, and none depicting riverine hunting. Some terrestrial scenes run contrary to the laws of physics and human and mammoth anatomies. Several artists recognized the crush and impact trauma hazards of terrestrial hunting by depicting hunters dead on the ground, picked up by mammoth trunks, thrown down, injured, or endangered by the towering weight and power of the mammoths. Arrows and spears are often shown hitting the mammoth in places unlikely to kill immediately. A number of exhibits and depictions display only the anticipatory or preparatory postures of hunters surrounding the mammoth, with maybe the first spear in touch with the mammoth or no spear at all yet in contact, which freed the artists from having to fully depict unknown hunting methods. Paintings of mammoths on pure white surfaces are not representative, since mammoths did not live on glaciers, much of the mammoth steppe occupied by mammoths was either arid with relatively little snow, warmer with green plants growing, or more southerly than depicted after seasonal migration.

Science and art assumed terrestrial procurement, and neither could formulate a reliable hunting methodology, image, or consensus. The obvious dangers of terrestrial procurement were graphically acknowledged in artistic portrayal.

The obscurity and incompleteness of mammoth procurement knowledge provides support for the authenticity, context, and meaning of the Předmostí Riverine Hunting Map Process Chart. The Interpreted Předmostí Chart was possible because the structures portrayed in ivory, and then in a drawing, could be formed into an effective, lethal, ingenious riverine killing zone that could kill mammoths fully in line with the laws of physics, both human and mammoth anatomy and physiology, tactical elevation and other hunting advantages, the known mammoth range, the most appropriate weapon, materials readily available, and the MNI levels obtained by riverine procurement generally. The Předmostí Chart is now the only identified or known depiction of the riverine hunting structures used successfully in Central and Eastern Europe. Further, it is the only identified Paleolithic depiction of the planned acquisition of mammoths in rivers or on land. With the other process charts, it helps reconstruct the mammoth palaeoeconomy.

Researchers of elephant hunting emphasize that before firearms it was a “dangerous, high-cost activity often associated with a high-risk of hunting failure.” (Lupo & Schmitt, 2024). In North America, terrestrial nomadic Paleoindians could not specialize in the hunting of *Mammuthus columbi, Mammut americanum,* or *Mammuthus primigenius* due to the danger and high energetic costs of hunting, tracking wounded animals, killing, and then processing that game. (Byers & Ugan, 2005). Use of sharpened iron spear tips in recent centuries does not provide an accurate ethnoarchaeological comparison, especially with over 40 hunters involved.

Forensic systems analysis of inchoate terrestrial theories of procurement challenges terrestrial Upper Paleolithic acquisition and transport *for the mammoths whose bones were accumulated in large amounts.* The impossibility or improbability of terrestrial mammoth procurement, sufficient to bring

multiple entire mammoth skeletons to any one settlement, is shown through taphonomic data and forensic systems feasibility and failure analysis. Inchoate explanations and scenarios suggesting or assuming terrestrial acquisition (in connection with MMBS) constitute a mix of mobile and sedentary systems and techniques, but without full coverage of the process from wild mammoth input to preserved and stored meat, fat, and inedible output. The incorrect terrain assumption caused uncertainties and resulted in doubts about whether mammoths were actually hunted and killed, whether hunters were sedentary, semi-sedentary, or nomadic, where mammoths were killed, how they were killed, whether a whole herd was killed at one time in a specific location, and provenance and provenience regarding mammoth bone accumulations. Incorrect terrain assumptions prevented hitting the scientific target.

7.2 **Doubts About Hunting**. As Djindjian recounts (Djindjian, 2015), hunting mammoths has been doubted and mass die-offs, scavenging and bone collecting favored by some for a century. (Chubur, 2014; Soffer, 1985: 258-259; Soffer, 1986; Péan & Patou-Mathis, 2003; Shydlovskyi et al., 2022).

Doubts continued: “As a result of zooarchaeological studies for several decades, it is known nowadays that the presence of large mammal remains in a Paleolithic site does not mean that this animal either has been hunted or even eaten by humans.” (Péan & Patou-Mathis, 2003). “First it must be told that it is still difficult to differentiate between hunting and fast access scavenging.” (Péan & Patou-Mathis, 2003). Milovice-G was either a “kill site or a quick access scavenge site.” (Péan & Patou-Mathis, 2003). “Paleolithic people seem to have trapped herds of mammoths (without old individuals) in specific natural areas before they killed them.” (Péan & Patou-Mathis, 2003). The possibilities of on-site killing and scavenging were considered as explanations for unexplained bone accumulations. (Wilczynsk et al., 2015; Svoboda et al., 2005). The origin of bone beds were either anthropic or natural or both per Iakovleva et al. (2012).

Alleged Prominence of Bone Graveyards & Natural Mass Deaths. Russian and Soviet archaeologists opined fairly early on, incorrectly in most cases, that accumulations of bones were natural mass die-offs (Haynes, 1991:315). Bones collected from these alleged mammoth graveyards were said to be what was used to build MMBS (Haynes, 1991:315), but provenience and provenance were never shown or attempted. The bones excavated at mega-sites appeared to be from healthy individuals and some showed cut marks indicative of hunting. Few mass die-offs from non-cultural causes were found. In time, with thousands of bones uncovered, the hunting acquisition of most of them became clear. Sites thought to be based on bone graveyards such as Kraków Spadzista in Poland and several others were later found to be hunting sites. The RP adds decisive weight to hunting acquisition over natural die-offs, bone collecting, and scavenging.

Russian-speaking Dr. Olga Soffer launched her scavenging, bone graveyard-seeking, and bone-collecting hypotheses soon after receipt of her Ph.D., work at Mezhyrich, and her unique visits to and extremely valuable and voluminous archaeological data from the Soviet Union during the Cold War, which gave her ideas outsized influence. (Soffer, 1985, 1986). In her 1985 tome, the chapter on Subsistence & Faunal Resources emphasizes the gathering of bones and the downplaying of “active hunting.” (Soffer, 1985: 258-259). In 1986, newly prominent Dr. Olga Soffer said, “that the role of the mammoth hunter has been vastly exaggerated, and that there was a good deal of collection of bones that went on with these

people." (Soffer, 1986). The annual bone-search was Soffer's 1985 speculation, repeated as late as 2022 (Shydlovskyi et al., 2022).

As Dr. Pat Shipman wrote in *The Invaders*, "The problem is figuring out how all those mammoths died in the same places." (Shipman, 2015b:182). Anthropologist Dr. Olga Soffer told her, "For God's sake stop buying the Hemingway myth that they killed every single mammoth—they settled near bone cemeteries and used them as lumber yards." (Shipman, 2015b:182).

The first scientific studies to prove with direct evidence (point in bone) the actual hunting of mammoths in Central Europe came relatively late. (Wojtal, et al., 2019). Scientists included scavenging or bone collecting as a procurement method (Pryor, et al., 2020; Wojtal et al., 2012; Bosch, 2012; Demay, et al., 2021a; Soffer, 1985). Shipman (2015a) briefly mentioned hydraulic transport of carcasses, and a few others suggested smoking of meat. Shipman made complex statistical calculations in an effort to determine how 86 mammoths were killed (Shipman, 2015a), but the answer is much simpler with reference to the most relevant contemporary documents, the direct evidence of four ivory process charts (the "ivories"), reliable accounts of the RP in operation, all of the mammoth hunters independently depicting the system used.

Hunter safety has not been explored in mammoth research, even though it deals squarely with the survival of the human and Neanderthal sub-species. Archaeologists and anthropologists spent much time establishing "possible evidence of mammoth hunting" from bones (See, Germonpré et al., 2008; Germonpré, et al., 2014). This tentative view of mammoth hunting undoubtedly stemmed in part from the intimidating thought of approaching woolly mammoths with a hand-held thrusting spear on even ground. Professional elephant hunters in the 21st century sometimes see their paid clients with powerful elephant rifles shrink when approaching a bull elephant to shoot it. No papers wrote about how Paleolithic mammoth hunters reliably, safely, and routinely killed woolly mammoths until the instant paper. Killing zones with massive spears were not simply clever structures and instruments. They were perhaps vital to the survival of *Homo sapiens*, which survival was in doubt during the LGM when human populations declined. (Schmidt et al., 2025). Earlier, before AMH arrived in Europe, similar hunting tactics may have helped Neanderthals survive for additional millennia.

7.3 **Doubts About MMBS**. Neanderthals built mammoth-bone structures (MMBS) with the defining characteristics at Molodova I-Layer 4 on the Dniester River before 44,000 years ago. (Demay et al., 2012). The mammoth-bone structures at Molodova I-Layer 4 mark the known beginning of the economic and physical pattern of MMBS. The possibility of Neanderthal sites at the very bottom of Kostenki layers, perhaps without MMBS, cannot be excluded. (Dinnis, et al., 2021). Neanderthals hunted straight-tusked elephants 125,000 years ago at Neumark-Nord, Germany (Gaudzinski-Windheuser et al., 2023).

Demay, et al. (2012:214) list an assortment of conjectures, mainly speculation, by different scientists regarding the purpose and meaning of MMBS at Molodova I-Layer 4, including (1) hunting blind (Binford, 1983), (2) natural accumulation (Klein, 1989), (3) circular symbolic ring bound to Neanderthal beliefs (Stringer & Gamble, 1993), (4) recurrent settlement where humans pushed away garbage and then built a centrifugal living structure (Kolen, 1999), (5) wind break for long-term occupation (Hoffecker, 2002), (6) monumental or ceremonial architecture; and to which list we could add

regarding MMBS elsewhere: (7) religious ideas of their creators (Gavrilov, 2024), (8) symbol of copulation at Mezhyrich (Baitenov, 2021, after Gavrilov), and (9) ritualized middens (Sablin et al., 2023). Ukrainian archaeologist and professor Oleksander Chernysh (1918-1993), the excavator who spent his career investigating and studying Paleolithic sites in Ukraine, specializing in Molodova, correctly opined the subject MMBS at Molodova I-Layer 4 was a dwelling with meat cooking and smoking. (Demay, et al., 2012:214, 224).

The diversity of conjectures listed did not favor nutrition, hunting procurement, or reference the RP or Dneister River on which all the Molodovan MMBS were located. Scavenging, non-systemic bone collecting or gathering, anti-hunting, and annual bone cemetery search hypotheses and writings lack any solid evidence, original provenience, or complete provenance. The motivation for gathering bones, scavenging, or moving to bone graveyards pales in comparison to more expedient survival and nutritional priorities in the Ice Age. The architecture and solid construction of MMBS invalidates the annual movement in search of bone graveyards.

The Upper Paleolithic hunting paradigm over decades steadily gained ground against the scavenger/bone collecting and hunt-doubting hypotheses on the issue of mammoth acquisition. (Musil, 2020; Agam & Barkai, 2018; Brugère et al., 2009; Germonpré et al., 2008; Pidoplichko/Allsworth-Jones, 1998:104). But consideration of “kill sites” and scavenging persisted. (Svoboda et al., 2005).

In 2009, the hunting of mammoths at Milovice was fully supported by archaeologists; 86 individual mammoth skeletons were found. (Brugère et al., 2009). Brugère et al. (2009) found hunting was the means of acquisition and presaged the River Paradigm: “During the excavation, several light hearths were found (around the bone deposits) which seem to have been low calorific hearths, in use for a short time. So a partial meat-smoking or drying activity practiced at these places is not excluded.”

Formation of theoretical terrestrial procurement systems in Central and Eastern Europe began under the doubts concerning hunting. Far from outlining the path from input to output, scientists could not agree about input. The results of terrestrial theories regarding input included the incongruous academic inventions of kill sites, fast-access scavenging sites, whole herds killed *in situ*, whole herds freezing to death *in situ*, impaling charging mammoths on spears held by humans, unrealistic artistic depictions, and annual searches for bone graveyards with which to build new MMBS.

Unknowns Generally include: (a) Accuracy of the dimensions and scale of the original, drawn, and interpreted Předmostí Charts. Originally drawn massive thrusting spears appear very long in relation to the depicted width of the Bečva River. (b) Exact number of hunters thrusting any one massive spear. (c) Exact design, length, diameter, slope of massive thrusting spears, physical spear grip, handles, and supports used. (d) Whether javelins, atlatls, or poison used in addition to spears and impaling points. (e) Specific design and tree species used to construct barriers barring exit of river. (f) Whether and to what extent stakes, spikes, or underwater obstacles used but not depicted in Předmostí Chart. (g) Whether any hunter ever killed a mammoth by striking a chisel-like stone weapon or dropping a heavy spiked log on the joint between the head and neck where mahouts drove chisels to kill their berserk war elephants; or lassoed a trunk held above water while mammoth swam with head underwater. (h) Several possible weapons or devices worked or applied jointly and simultaneously by hunters on each oval. (i) Whether the killing zone

and massive spears detected at Předmostí can by archaeological analogy be expected or assumed at other mammoth sites. (j) Constraints on site occupation.

8.0 Comparative Systems Analysis of the River Paradigm

8.1 **Testing Hypothesis of Sedentary Riverine Hunting**. The RP is proposed as a systematic, multi-phase procurement and processing system that generated productive, allocative, and organizational efficiencies compared to nomadic and terrestrial hunting strategies. The ivory process charts and bone-processing models presented herein depict mammoth carcasses being transported by river to multi-purpose mammoth-bone structure (MMBS) settlements. Mammoths represented exceptionally valuable prey because their edible tissues contained substantial quantities of both fat and protein (Agam & Barkai, 2016), in contrast to many lean ungulates and herbivores (Speth, 2025). From the perspective of Optimal Foraging Theory, a procurement system that reduced transport costs and facilitated the acquisition of high-return resources conferred significant advantages.

The two principal mammoth-procurement lifeways discussed here—sedentary riverine hunting versus nomadic or terrestrial hunting—represent contrasting organizational strategies. Existing terrestrial transport models for mammoth carcasses, skeletal elements, or bone accumulations remain incomplete in many respects, particularly when applied to the large concentrations of proboscidean remains associated with MMBS settlements. In contrast, North American mammoth-hunting populations generally remained mobile and did not construct MMBS settlements or accumulate comparable quantities of proboscidean skeletal material.

8.2 **Controllable Navigability Needed**. Riverine site placement was governed by the size of the rivers chosen. Large rivers such as the Danube, Vistula, and Dnieper were too wide to control with structures, traps, and barriers, especially at flood stage. Exceptions are Langmannersdorf on the Danube and the Kostenki-Borschevo settlements on the Don River. Perhaps the Don is and was a lowland river not reliant on mountain runoff; hunters took mammoths upstream on the Divitsa and Veduga tributaries and floated them to the Kostenki-Borschevo sites; the high hills at Kostenki-Borschevo limited river meandering; or because unknown trapping structures were used that may or may not have required blockage of the entire river width or used submerged obstacles that held mammoths securely. The lower limit of river size was navigability, the necessary volume of water, at least during spring flood stages, to float mammoths down to settlements. Lower river volume may have supported hunting bison, horses, reindeer, and other large mammals. Terrestrial procurement of mammoths is not wedded to rivers, although instances of presumed terrestrial procurement may actually be riverine procurement. If mammoth hunters built killing zones on large rivers, those structures would have zero chance of preservation. It is possible mammoths crossed large rivers seasonally and at predictable crossings.

8.3 **Input and Output Relationships**. Within the RP framework, whole mammoths, other ungulates, and trapped fur-bearing animals constituted primary inputs, while outputs included food stores, MMBS construction materials, tools, artwork, ornamentation, clothing, and large bone accumulations. Archaeological evidence from Mezinian contexts demonstrates the extensive use of mammoth skulls and tusks in MMBS architecture. The concentration of diverse products derived from mammoth procurement suggests a highly integrated economic system.

8.4 **Production Speed and Volume**. By dividing procurement and processing into specialized and repetitive stages, the RP increased operational efficiency and reduced uncertainty during hunting episodes. Repeated use of familiar riverine environments enhanced predictability in both mammoth behavior and procurement outcomes. In contrast, terrestrial hunting episodes likely varied considerably according to local terrain, prey movements, and logistical requirements, requiring unique actions and tactics.

8.5 **Hunter Safety Comparison**. The River Paradigm acquisition model discussed and depicted above (§6.3, Fig. 5A) shows how woolly mammoths could be taken safely by providing point-of-operation, distance, and barrier guarding between hunters and mammoths. (see generally, OSHA Standard 1910.212). Terrestrial hunting of mammoths on open ground as commonly depicted or studied could not be performed safely. Mammoths on land posed risks of crush and impact trauma, bodily harm, and death, which risks are reflected in multiple depictions of terrestrial mammoth hunting. Acknowledged dangers of terrestrial mammoth hunting on open ground were never specified by scientists with any description, theory, or techniques concerning how the mammoth would be killed after the first thrust of a spear into the mammoth or how crush and impact trauma would be avoided. Massive thrusting spears actually used were many times more powerful than hand-held spears thrust by individual hunters and could avoid the frontal dangers posed by powerful trunks and large tusks.

8.6 **Specialization**, **Centralization**, **and Division of Labor**. The RP concentrated construction, maintenance of structures, butchery, food and tissue processing, bone working, ivory carving, and lithic production within a central settlement, facilitating occupational specialization and cooperative labor organization. Nomadic hunters faced a more dispersed allocation of labor and resources.

8.7 **Efficient Resource Utilization**. Riverine transport reduced losses to scavengers by enabling rapid movement of carcasses from procurement locations to processing sites. Cold-water environments aided preservation prior to butchery. Because whole mammoth carcasses would have been extremely difficult to transport overland, river transport increased the proportion of carcass resources available for human use.

8.8 **Scalability and Flexibility**. The RP could potentially accommodate prey of varying sizes and species while supporting multiple processing activities. Smokehouses, storage facilities, and curated tool assemblages may have increased the flexibility of settlement-based production systems. Nomadic groups, constrained by transport limitations, would have faced greater restrictions on the quantity of tools, hides, and processing equipment they could carry.

8.9 **Protection from Environmental Conditions**. Relative to portable shelters, MMBS dwellings provided superior protection from wind, precipitation, snow, and low temperatures. Their substantial construction and insulating properties may also have improved security against predators and facilitated year-round occupation. The large spears depicted in the Předmostí Chart indicate that some of the river structures and spears were portable, although fixed structures may not have been protectable from destructive high-energy flooding.

8.10 **Feedback Loops and Dynamic Efficiency**. Upper Paleolithic mammoth-hunting communities functioned simultaneously as producers and consumers. The relatively small scale of these groups enabled rapid feedback regarding resource allocation, technological innovation, labor organization,

and social decision-making. Repeated use of established procurement locations probably reduced operational uncertainty and facilitated cumulative improvements in efficiency.

8.11 **Warm-Weather Outposts**. It is postulated that seasonal procurement in upstream river segments involved temporary warm-weather outposts equipped with portable shelters, such as chooms or tipis (1) located to monitor and live near paleo-fords where mammoths, bison, horses, and reindeer were more likely encountered, and (2) as temporary shelter near killing zones. MMBS settlements were generally situated at lower topographic elevations, whereas higher-elevation sites have been interpreted as warm-season camps (Shydlovskyi et al., 2022). Within the RP framework, these seasonal camps are hypothesized to have functioned as satellite procurement stations linked to permanent MMBS base settlements where butchery, meat smoking, fat rendering, storage, and craft production occurred (Gleissner, 2025). This model predicts that future investigations will identify warm-season camps in close spatial association with the same river systems occupied by MMBS settlements.

Within this framework, Upper Paleolithic mammoth hunters maintained a persistent ecological orientation toward the rivers on which they lived and through which mammoth herds regularly moved. The River Paradigm therefore proposes a close functional relationship between riverine environments and mammoth-hunting societies, with rivers and distinct zones therein serving as central elements in procurement, transport, processing, and settlement organization. Hunted navigable rivers consisted of three zones: the chase zone in which mammoths were directed downstream to killing zones, killing zones, and then transportation zones in which mammoth carcasses were transported downstream to the docks of settlements. The specific production activities that constitute the River Paradigm, including the three hunting zones and the five phases of the mammoth palaeoeconomy, are presented in chronological order in §11.0, Hunting Zones, Sequential System Model of Production Activities within the River Paradigm, and Tactical Reversal Schedule.

8.12 **Wide communal participation**. In the river, mammoths were heavily outnumbered by hunters and dogs. The popular depiction of Paleolithic mammoth hunting usually involves only male spear hunters, but Bebber et al. (2023) showed that atlatl use equalized female and male projectile weapon velocity. Protected hunting positions, massive, long thrusting spears with lubricated fulcrums, distal spear supports, poison, atlatls, the need for dog handlers, and any drum use for driving or signals enlarged the ranks of mammoth hunters to include women and teenagers. “Early subsistence economies that emphasized big game would have encouraged participation from all able individuals.” (Haas et al., 2020). All adults could hunt.

9.0 Comparative Systems Analysis by Five (5) Sequential Phases of the Mammoth Palaeoeconomy

9.1 **First**: **Initial Procurement**. Procurement in rivers assured human control of both hunting activities and the prey carcass. Riverine terrain was the key feature in the RP mammoth procurement strategy and permits basic spatial analysis of site location, procurement, and river transportation. A barrier, trap, or snare could stop downstream movement, wound mammoths with underwater sharp points, or keep mammoths immobile and subject to projectiles or spears from safe positions (see Fig. 5A).

The exact hunting techniques are not critical to proving the RP, because we have input and output data, but tactical elevation reversal seems to prove the RP. The causes of mammoth hunting deaths

included blood loss, fatal injury to vital organs, poison, drowning, shock when sensitive trunks were pierced, asphyxiation when trunks and trachea were blocked, and various internal injuries. The Předmostí killing zone was able to achieve these mechanisms of death after mammoths lost their terrestrial advantages.

Firing weapons at mammoths swimming downstream was difficult if the mammoths swam submerged with only their trunks and maybe head tops and backbones exposed; but snagging, catching or lassoing those trunks at water level with the mammoths' eyes underwater may explain the Kyiv-Kirilovskaia mammoth's tied distal trunk.

Ambushes at paleo-fords probably sought to induce mammoths and other game to swim downstream, perhaps by simultaneous hostile confrontation from each side of the river. Serious attack did not have to start until mammoths were in killing zones. Swimming underwater downstream, mammoths avoided the sight and lessened the aggravating sounds of barking dogs, drums, shouting, projectile attacks, perhaps swimming calmly for several kilometers until entering a killing zone similar to the Předmostí killing zone. Mammoths were good swimmers and dogs great runners, so mere distance was not a significant obstacle. Submerged swimming or just floating mammoths escaped the initial ambush and extended pursuit until reaching the killing zone.

A variety of advantageous procurement techniques explain some natural advantages of riverine terrain. Large mammals tend to take the path of least resistance in terrain, favoring lower passes; and are often hunted at any terrain funnels. (Kayser, 2025). The river downstream was the lower path of least resistance when mammoths were confronted by dogs and hunters, and mammoths were likely already in paleo-fords.

Anthropogenic bone accumulations sex ratio. Moots et al. (2026) found through DNA from dispersed sites versus DNA from anthropogenic bone accumulations (Mus-Khaya, Langmannersdorf, Kraców Spadzista, and Dolní Vestonice I) that

> mammoths from dispersed sites show a male bias (~66.5%), which is consistent with the heightened vulnerability of solitary males to hazards such as natural traps, where bones are more likely to be preserved, whereas mammoths from anthropogenic bone accumulations are predominantly female (~70%). This female bias is pervasive across multiple sites, indicating an anthropogenic origin for these accumulations as a result of Upper Paleolithic hunters preferentially exploiting female mammoths, possibly derived from herd contexts. (Moots et al., 2026:Summary).

Moots et al. (2026) confirm the RP by finding the hunted mammoth bones in four mammoth-hunting settlements situated on rivers, whereas the dispersed mammoths were said to succumb to natural traps or other natural mortality and were not hunted. Anthropogenic bone accumulations generally result from riverine hunting, and when the MNI exceeds about three (3), they all do. Dispersed mammoth bones do not reveal much hunting. Riverine hunting harvested predominantly female and frequently younger, sub-adult, or juvenile mammoths, which is consistent with matriarchal herds being surprised in paleo-fords or while swimming, perhaps on both sides simultaneously, and some of the herd and younger individuals opting for the river escape. Younger and female mammoths would experience deeper water than adult males, who could more likely touch bottom or regain footing. Paleolithic terrestrial hunting of matriarchal

herds was very difficult due to protection by matriarchal and adult female mammoths, many eyes, ears, and noses detecting humans, and younger mammoths following the direction of the matriarch and herd. Riverine hunting was a way to break up the herd.

Lower acquisition costs. By hunting, killing, and transporting mammoths in the same river or riverbed, the higher acquisition costs of finding, hunting, killing, tracking, and transporting mammoths was reduced over mobile or nomadic hunting. Nomads had to find and track mammoths around 360-degrees of unfamiliar and uneven terrain, bushes, trees, and obstacles, for as long as it took the mammoths to die. The rivers allowed hunters to create pre-positioned stands, platforms, barriers, and underwater impalement devices, giving hunters a shot with their atlatls, javelins, spears, or bows & arrows across or within water, and constrained mammoth movement. To these lower acquisition costs, we must add the prodigious labor and material costs of creating and maintaining the river structures and massive spears, dog maintenance and care, and hunting labor along stretches of river.

Logistical hunting efficiency compared to nomadic hunting. Nomadic hunters would sometimes drive mammoths away from themselves, with mammoths selecting escape routes. Sedentary hunters drove mammoths toward their riverine killing zones, tissue processing, and storage facilities on pre-determined river routes, denying escape from the river. Water brought the entire carcass in pristine condition to the MMBS settlements.

Longer vulnerability within rivers. In the rivers, mammoths were sometimes subject to atlatl and spear attacks. Mammoth behavior within rivers was more predictable. With nomadic hunting, unless the lone bull mammoth was surprised with a belly thrust of a spear while asleep or distracted, the mammoth had to be chased, and hunting distance re-established, if possible, in open terrain with alert prey.

Hunting Dogs. Evidence of Paleolithic dogs has been found at three Mezinian MMBS sites: Mezhyrich, Mezin, and Eliseevichi (Germonpré et al. 2009), and at Předmostí. In *Our Oldest Companions*, Shipman observed a strong connection between dogs and mammoth hunting (Shipman, 2021:16, 27, Ch. 5-What is Domestication?). Gemonpre & Sablin (2017) found large canids, including wolf (*Canis lupus*) and/or dog (*Canis familiaris*), co-occurred with woolly mammoths (*Mammuthus primigenius*) much of the time. (Germonpré & Sablin, 2017:Table 2.1). Dogs substantially aided the hunt for mammoths and other game and likely kept mammoths in rivers during hunts. Sedentary mammoth hunters obtained massive quantities of dog food with which to tame, train, feed, entice, domesticate, and selectively breed dogs, and bait wolves. The author's unidentified-structure opinion (Gleissner, 2025:10) regarding the Mezhyrich Process Chart is now withdrawn and the opinion given that those shorter structures were a line of dog kennels.

Enhanced Hunter Safety: Dangers of Close-contact Hunting Avoided. The RP reduced or eliminated unsafe close-contact mammoth hunting and eliminated fights with predators/scavengers over carcasses and parts transported overland. High mammoth harvest numbers could not have been achieved if there was even a 5% chance of death or serious injury from close-contact hunting of one mammoth or hypothermia.

Supporters of terrestrial acquisition agree that hunting massive, strong, fast-moving mammoths was dangerous, required organization and the most advanced weapons, was difficult to confront if in a herd, often required multiple spear-strikes to kill, and that hunters surely took advantage of, among other

things, mammoths' inability to go up or down steep slopes. (Demay, et al., 2021b: 207). The RP minimized or eliminated close-contact hunting (Fig. 5A).

Poison. Mammoth vital organs were very well-protected by ribs, bones, hides, hair, fur, tusks, skulls, trunks, and the terrestrial speed and strength of mammoths. The evidence of lithic-bone contact at Kraców Spadzista is to the *lateral side of ribs* (Wojtal, et al., 2025), suggesting the use of poison over time and distance (not mortality from reaching vital organs or blood loss) or the superior lethality of massive thrusting spears revealed by the Předmostí Chart (Fig. 5A). Close-contact mammoth hunting was dangerous based on Neanderthal skeletal findings, ethnographical data, and common sense given the lopsided weight and strength imbalances. Most atlatl darts, arrows, and javelins did not penetrate enough to kill mammoths, especially because they had to travel through carpet-like thick hair and fur, then hide, then subcutaneous fat, and tough tissues. The use of poison in multiple piercings could reliably kill, slow, immobilize, or disorient mammoths without risking close-contact hunting, but poison took time. At Předmostí, poison would be more effective if used earlier in the chase zone or anytime the mammoth presented a target, but in the killing zone would not have time to affect the outcome. Poison was possibly used more for terrestrial hunting of reindeer, horse, or bison, which could be hunted with dogs after initial poison injection.

Use of poison might help explain the very limited number of point-in-bone findings and such findings to the lateral side of ribs, although the use of massive thrusting spears probably explains this better. Poison only had to enter the bloodstream, not traumatically damage vital organs or cause excessive loss of blood. Poison worked faster in the bloodstream if the mammoths were then driven. (Borgia, 2019).

Poisons commonly used by indigenous hunters across the world varied as to the plants, animals, and insects used for various formulas, and as to the physiologic action induced (Prance, 1999) in the nervous, respiratory, gastrointestinal, cardiovascular, or renal systems (Riede & Lombard, 2024). Use of natural aconite poison was widespread among indigenous hunters throughout East Asia and into the Aleutian Islands (Heizer, 1938). Various beetles are poisonous. Some modern elephant poachers, wary of the ban on shooting elephants, reverted to using easily produced yet potent natural Acokanthera poison administered by spears or arrows (Micheni).

Controlled and shortened persistence hunting. The channeling of mammoths downstream, attacks with atlatls or javelins, the use of barriers and underwater obstacles in the river, and the safety required for thrusting spear attacks, together constituted a form of controlled persistence hunting. (see Fig. 5).

Second: **Transport**. Mammoth carcasses were floated to settlements and docked directly below settlements, as clearly shown by the process charts of Mezhyrich, Eliseevichi, and Kyiv-Kirilovskaia. How far they could be floated is unknown, but during times of high river water, floating was made easier.

Energetic transportation costs minimized. Water transport was maximized while terrestrial transport was minimized under the RP. We may assume mammoth hunters made a rational choice to maximize their net rate of energy gain (calories in versus energy/time spent). Water transport of mammoth carcasses was exponentially more laborsaving than terrestrial transportation of mammoth parts, bones, and carcasses. Nomadic hunters would have to move smoking chooms, meat/fat racks, tools, and containers to each kill site if they even progressed to those more sophisticated manufacturing tools.

Energetic analysis based on weight and distance. If a 4,000 kg mammoth was killed on land five (5) km from a settlement, the 67 kg mammoth people, if they could each carry 50 kg of mammoth tissue, and the mammoth butchered completely and precisely into 50 kg packages, would have to walk a collective total of 800 km on uneven terrain under their heavy loads, making 80 10-km round trips = 160 5-km one-way trips. Of course, mammoth bones and hides could not be divided neatly into 50 kg packages and carrying that much weight would require back-packs and reduction in load for smaller individuals. Large bones with meat attached and particularly skulls with brains and tusks would prove difficult to impossible to move on land. Dr. Gary Haynes wrote: "heavier elements, such as skulls with tusks, would seem to have been excessively troublesome to transport any distance." (Haynes, 1991: 209). Transportation of entire mammoth hides would not likely be possible given their weight, bulk, and attachment to subcutaneous fat.

Labor costs to defend against predators works against terrestrial systems. Carcass fights over the huge carcass would have been inevitable. Each mammoth person in transit would be subject to attack by wolves, hyenas, brown bears, lions, eagles, or wolverines, and the annoyance of flies, birds, arctic foxes, etc. Some of the strongest hunters might have to serve as guards ready to repel wolves, brown bears, and lions. Guarding would require a convoy system, which convoys would require additional time to schedule and organize. Labor requirements for guarding of carcasses and meat in transit was not necessary under the RP.

Schlepp effect reduced to zero. In the RP, waste from the Schlepp Effect was virtually eliminated. In nomadic hunting, the Schlepp Effect could be significant in terms of waste.

9.3 **Third**: **Initial Butchery**. Four process charts show mammoth carcasses in the river, and one chart depicts the river and site improvements. Butchering in the river, which meant butchering in the boat formed by the partially butchered mammoth, required that the soft belly be up, not the backbone. Spoilage and contamination were lessened because the carcass was in great condition compared to terrestrial procurement. Poisons did not affect tissue edibility. Meat and fat were likely placed in baskets by the butchers and then walked to their processing stations. Smokehouses immediately protected meat and fat from flies. The entire mammoth hide might be available at the end of RP butchery but had to be cut up as part of butchery on land, since portions of hide would also be transported if the entire mammoth was utilized.

The RP provided delivery in rivers, secure docks within settlements, and river moats surrounding butchered carcasses. Some terrestrial assumptions came with the belief the MMBS settlements were "butchery sites," and in this regard they agreed with the RP, but not as to the exact location of the butchery. Speculative terrestrial butchery is portrayed in Upper Paleolithic archaeological literature very differently than the actual Paleolithic butcherers performed and memorialized it: Process charts *versus* Demay et al. (2021b: Fig. 7.2), which shows a standing mammoth with butchery stages as with domestic cattle. Nevertheless, it is correct to regard MMBS sites as "butchery sites," because river-procured mammoths were butchered in the rivers directly below settlements.

9.4 **Fourth**: **Processing of Mammoth Tissues**

9.4.1 **Processing of Edible Mammoth Tissues**. Cold-Smoking, full drying, and fat-rendering were the Paleolithic options to preserve meat and fat and may have begun with *Homo erectus* during the

Lower Paleolithic (1.9–0.78 Ma) (Ben-Dor & Barkai, 2025). The Kyiv-Kirilovskaia Process Chart provides two different smokehouses or processing stations. One was for smoking meat, and the other for rendering fat, given that mammoths' edible tissues were 50% meat and 50% fat. Instead of industrial-level processing in large, dedicated structures, the terrestrial theories did not specify how the edible mammoth tissues were processed, nor did they claim sufficient edible tissues to fill up the size of smokehouses at MMBS sites. Terrestrial theories did not speculate how much meat and fat were brought home to MMBS sites, and they never speculated that 100% of mammoth carcasses would be available at MMBS sites.

To preserve meat and fat in Paleolithic times, moisture had to be removed through cold-smoking, full drying, or fat-rendering. Those were the only practically available options for full preservation. Fully dried meat could be smashed with rocks and placed with rendered fat to make pemmican (Speth, 2025). Fat must be rendered with heat to remove moisture, but pure fat is easier to render than from other tissues. Neanderthals 125 kya had to work very hard just to obtain bone grease (Kindler et al., 2025), which shows how prized proboscideans and fat were. Cold-smoked fat (semi-preserved fat) resists bacterial invasion with wood smoke phenols, including guaiacol & syringol, organic acids that lower surface pH, and physically after a crust is formed around the unrendered fat (Park City Culinary Institute, 2025).

Smokehouses were probably used for cold-smoking, fat-rendering, complete meat drying, and meat roasting. To conserve fuel, they may have cold-smoked, fully dried, and rendered fat at the same time, with the same fire perhaps in the same smokehouse, but procedures undoubtedly varied by separate structures, bands, and MMBS sites. Outside and external hearths were used, perhaps with movable chooms or in open air.

The mammoth people with MMBS probably prepared pemmican as most hunter-gatherers did, with half dried meat and half rendered fat, whatever fruits or other substances could be added to improve taste, and then the food sewn into a hair-out bison hide (Speth, 2025). Paleolithic hunters needed fat. (Speth, 2025). Pemmican did not taste very good (to modern tastes), and its continued use should be attributed to the necessity of fat consumption to avoid rabbit starvation (protein poisoning) (Speth, 2025). Sodium chloride may have been obtained at Mezinian and Kostenki sites by leaching in water the salty tephra deposited by the 39.5 kya Campanian ignimbrite eruption. (Ayris, et al., 2015; Hawaiian Volcano Observatory).

Processing of some mammoth organs was not required. If mammoth hunters ate the livers, kidneys, spleen, brains, and hearts raw, consumed the undigested dietary fiber in mammoth intestines, ate smoked meat with wood smoke phenols (including guaiacol & syringol), ate a few fish or mollusks from rivers and streams, and consumed the ubiquitous berries found on the mammoth steppe, plus maybe a couple of additional plant foods, they would have with meat and fat close to all of the necessary vitamins, minerals, nutrients, fiber, and calories needed for survival. (Sheffield et al., 2024; Devore et al., 2012; Guil-Guerrero, 2023). Mammoth hunters may have consumed putrid fat or meat or lightly smoked fat or meat that was then allowed to putrefy (Speth, 2025), perhaps as a specialty.

Potential energetic value maximized. Starting with tons of raw carcass, the material yield was great, as 100% of huge mammoth carcasses were delivered to docks. The RP very likely extracted the highest obtainable percentage of the mammoth's potential energetic value. This was true compared to nomadic hunters, and it is likely still true today for many elephants killed on land with high-powered rifles

in Africa. Some 70% of the energetic value came from fat (Speth, 2025:5). To people threatened with starvation, mammoths were bonanzas.

Just-in-Time Manufacturing. Butchery started after the conveyor belt of water delivered the bulk material to the docking position. Raw tissues were taken directly to processing locations within the settlement. Smokehouses loaded with meat and fat could commence food processing soon thereafter. Fat could proceed directly to rendering, could be semi-preserved with cold-smoking and rendered later, eaten semi-preserved, or fed to dogs before rendering. Processed meat and fat were taken to elevated meat/fat caches. These labor-saving steps were unavailable to nomadic hunters.

Improved Workflow Efficiency: Moving materials via river with minimal routine terrestrial transportation maximized productivity. Constructed smokehouses were superior in several ways to nomadic choom smokehouses, although MMBS people may have used chooms for cold-smoking in their settlements or for summer habitation.

Lowered Production Costs (Economies of Scale): High-volume bulk production spreads fixed costs like smokehouses, dwellings, and weapon and clothing manufacturing, over more edible packages, lowering the cost per package of meat and fat. Nomads had to set up meat processing at kills and could not reasonably transport edible tissues back to a base camp. Nomadic cold-smoking could not easily be performed in one large batch due to the weight of smoke containment hides or limited number and use of chooms.

Consistency & Quality Control: Standardized processes using the same hunting, transportation, butchery, slope steps, ravines, smokehouse racks, and smokehouses allowed for more uniform products, reducing variability and defects. Consistency of mammoth procurement is demonstrated in MMBS with foundations made of many mammoth skulls.

9.4.2 **Processing of Inedible Mammoth Tissues**

Multi-purpose Mammoth-bone Structures (MMBS). At Mezhyrich (109 MNI), there were four MMBS, external hearths likely used with choom smokehouses or fat rendering stations or open air fires, and four elevated meat/fat caches. Construction of single-use structures, other than elevated meat/fat caches, either MMBS or portable chooms, would take too much material, time, and energy if not absolutely necessary. Structure needs included cold-smoking, fat-rendering, all-weather habitation, wood & plant storage; civic, religious, ceremonial, and social meetings; sleeping and family quarters; lithic, clothing, material, tool, and weapon manufacturing and processing; and portable choom use for warm-weather outposts, cold-smoking, or storage. For a list of useful products, see Gleissner (2025).

9.5 **Fifth**: **Storage** in **Elevated Meat/Fat Caches**.

The ivory process charts from Mezhyrich and Eliseevichi depicted elevated meat/fat caches. The ivories confirm the long-standing use of elevated meat/fat caches, which structures are still in use, and the completeness of the economic system known as the RP. Prior storage theories included storage in cold ponds, underground storage with all its problems, and frozen storage in indefinite structures. Looking at diagrams and photographs of Kostenki 11-1a (64 MNI), several small bone piles with long bones and even tusks outside the MMBS might well represent several fallen elevated meat/fat caches (Pryor, et al., 2020: Figure S4), less the original wood components of same. One or two backward “C”s in the Eliseevichi Chart, on land, seem to be tusks providing lateral and vertical support for elevated meat caches (Gleissner, 2025: Fig. 4).

Binford (1980) wrote that foragers seldom store food. Elevated meat storage provided protection against predators, pests, bacteria, and potential contamination. For indigenous peoples, above-ground storage is much more common than in-ground storage (Speth, 2025). Soffer (1985: 255) found that the underground storage in the Upper Paleolithic Russian Plain held mammoth, horse, and reindeer bones and antlers, not meat. Elevation promoted improved air circulation and circumvented the challenges associated with excavating and securing permafrost.

Meat stored in the river did not progress to rancid condition while frozen or when surrounded by frigid water (Fisher, 2021). Carcasses during riverine butchery were cooled from cold river water across the submerged part of mammoth carcasses.

9.6 **Constraints Drove the System**, **Revealing Opportunities**. To achieve economic viability, mammoth hunters had to utilize the only logically efficient methods available to them. The strict environmental limits of the Paleolithic Ice Age support riverine procurement over terrestrial models. Mega-sites were restricted strictly to navigable rivers. The river supplied hunting advantages and transportation of carcasses. Processing at the river dock maximized water transport, minimized part portage, placed butchery directly below settlements, and excluded predators. Moisture removal was the sole practical method to preserve meat and fat, which was then protected from scavengers using elevated caches. Because this subsistence system operated via the only viable efficiencies, the RP endured for 26,000 years, limited by constraints of climate lasting centuries or millennia and other factors not yet understood. The process charts serve as reliable, eyewitness and physical proof of the RP. River hunting was mandatory to reliably overcome mammoths and transport them to MMBS settlements and also implicit in the process charts.

10.0 Hunting Zones, Sequential System Model of Production Activities within the River Paradigm, and Tactical Reversal Schedule

A. **Three Hunting Zones in Navigable Rivers**:

Chase Zone >> | Killing Zone >> | Transportation Zone >> *Docked Below Settlement*

>>>>> *Flow of River* >>>>>

Length of zones and distance between zones and to settlements are unknown. The chase zone may have included meandering, multiple, or braided river channels, which would put much more work on the dogs or have required drives, drivers, drums, fires, smoke, and/or loud noises.

B. **Sequential System Model of Production Activities within the River Paradigm**

[with five (5) basic phases of mammoth palaeoeconomy marked **in red**]

Siting of MMBS near navigable rivers on sufficient elevation ===➔Location of paleo-fords and establishment of upstream warm-weather hunting camps ===➔ preparation of river chase zones, killing zones, massive spears, and transportation zones on navigable rivers ===➔ mammoths (or other ungulates) observed (in or out of river) when river conditions favorable ===➔ mammoths allowed to enter river or driven into river by humans, dogs, or fire; mammoths chased downriver ===➔ **mammoths killed** in killing zones ===➔ mammoths **floated downstream via river to dock below settlement**, as depicted in process charts ~~~ or sank underwater initially and rose to the surface after passage of time ~~~ or

anchored underwater and stored in cold river water for processing later ===➔ whole mammoths docked and secured to the riverbank belly-side up with ropes, cords, or long bones, and wood or bone walkways, docks, or platforms built to assist butchery and access to mammoth carcass, as depicted in ivory process charts ===➔ **docked mammoths initially butchered** with stone knives, microliths, axes, etc., as depicted in Eliseevichi Process Chart ===➔ first tissues from mammoth belly likely given to domesticated dogs (or wolf-dogs or wolves assisting the hunt) as regular immediate operant conditioning rewards ===➔ edible mammoth parts taken in baskets to smokehouses for fat-rendering, cold-smoking, or complete drying, as shown in Kyiv-Kirilovskaia Process Chart ~~~ some meat & fat was consumed raw, perhaps vitamin-rich organs, or after roasting or other more immediate meal preparation ===➔ **cold-smoking**, **fat-rendering**, or **full drying** of edible mammoth tissues not consumed immediately ===➔ non-edible tissues taken to bone beds in ravines, work stations for bone, hide, organ, collagen, sinew/ligament, and tusk ivory processing, utilization, artistic use, or tool-making ~~~ some bones used for fuel in smokehouses to slow combustion of wood fires ===➔ **stored in elevated meat/fat caches** (rendered fat and smoked or fully dried meat) ===➔ consumption of meat and fat when needed or desired ~~~ multiple uses for bones, hides, organs, ivory tusks, collagen & sinew/ligaments.

C. Tactical Reversal Schedule

Advantages Lost by Mammoths & **Consequences** = **17**

Mammoths Lost –» **Consequences of Paradigm Shift to Riverine Environment**

Footing –» due to river current, buoyancy, river bottom uneven, rocky, or soft; perhaps spikes

Mobility –» river channel, barriers, river current, & slopes minimized or ended mobility

- Escape –» escape ideation replaced by killing zones; could not flee to escape danger
- Charging –» not possible due to lack of traction and inability to charge humans or dogs
- Fighting –» could not counter-attack hunters
- Keeping distance from hunters –» distance from hunters and dogs remained close
- Ran away from danger –» floated & swam toward killing zone

Greater strength –» No gravity, friction, stance, or footing to use strength

Decision-making –» Almost no decisions available after immersion, persistent current, confinement & chase

Greater weight –» weightless in water, as buoyancy counteracted weight

Superior height & elevation –» inferior height and elevation in navigable rivers

Aggressiveness –» lost ability to apply blunt force trauma to and crush hunters

Clear vision –» vision underwater problematic or opaque

Familiarity with terrestrial terrain –» Riverine terrain unfamiliar while immersed

Movement with anticipated destination –» Involuntary movement to unexpected killing zone

Dominance –» became vulnerable to attack without ability for dominance displays or action

Ability to smell –» reduced olfactory value, since limited mobility, use of trunk & decision-making

Unimpaired hearing –» sounds muffled underwater

Size –» became liability due to targeting in confined & predictable locations

Vulnerability to hand-held weapons at distances –» vulnerability to massive thrusting spears & hand-held weapons at closer distances
Superiority against dogs –» more intimidated by dogs as to barking, proximity, tactical elevation, inability to escape them; dogs on pathways, dogs outnumbered mammoths and worked with humans; dogs kept mammoths in rivers
Value & protection of herd –» isolation from herd in river; protection of herd lost

Advantages Gained by Hunters Over Mammoths in Riverine Hunting Environment = 23

Footing
Mobility
Superior height/elevation
Greater applied strength
Decision-making ability
Greater applied weight
Aggressiveness
Clear vision with many sets of eyes
Familiarity with terrestrial & riverine terrain
Movement with anticipated destination
Dominance
Unimpaired hearing, including sound of dogs and thus approaching riverine mammoths
Size of large target
Pre-positioned massive thrusting spears used (best Paleolithic hunting weapon for mammoths)
Mechanical ability to bring maximum force to single spear points
Projectiles & impalement employed
Use of hunting dogs
Hunter safety: guarded against blunt force trauma from trunks, tusks, feet, knockdown & trampling
Element of surprise (at paleo-fords, during riverine movement & at killing zones)
Site preparation (building barriers, impalement, pre-positioned massive thrusting spears, fulcrums, closing ravines, etc.)
Teamwork involving multiple hunters and weapons
Tactics & techniques available: pits (river = extended pit), persistence over several km, ambush, poison, elevated stands, etc.
Knowledge of likely behavior based on earlier riverine hunts

11.0 Abandonment of MMBS Sites & **Future Research**. “People become sedentary when nature provides a sufficiently rich and reliable assortment of resources at a single location.” (Dow & Reed, 2015). The prevailing archaeological thought now is that MMBS settlements were occupied all year (Demay et al., 2020), and the RP verifies sedentism. Sedentism increased fertility. (Page et al., 2016).

The number of years individual MMBS sites were inhabited in one occupation before abandonment, leaving one cultural layer, cannot easily be determined and did not correspond to the wide

ranges of radiocarbon dates obtained within MMBS sites. Dividing the number of skulls or skeletons found in MMBS by three (3), dependent upon the number of mammoth people at the site, may result in a very approximate estimate of the number of years occupied. Mezhyrich was occupied for 50 years (old count) or 36.3 years (new count) under this divisor. Estimates of various Mezinian mega-site human populations run from 30 to 50 to 70 to a maximum of 100 per mega-site. (Pidoplichko/Allsworth-Jones, 1998:164), so the divisor should probably increase with populations over about 30 to 40 inhabitants. Populations can best be determined by the number of MMBS with thick walls, and there seems to be a convergence of Mezinian sites at about four (4) or five (5) MMBS with thick walls.

The Mid-Dnieper basin was depopulated for 5,000 to 6,000 years, from 25/24 kyr cal BP to 20/19 kyr cal BP (Chabai et al., 2020), due to cold climactic conditions, including a Heinrich event at around 23,000-21,000 ya. Structure 4 at Mezhyrich was precisely dated recently to 18,248 to 17,764 ya. (Chu, et al., 2025). Mezinian Culture may have abandoned the Middle Dnieper River Basin after the abrupt arrival of Heinrich Event 1.

We find the periodic abandonment of MMBS sites after probably decades of occupation, which would not always meet the more stringent definitions of sedentism (Dow & Reed, 2015), followed by re-occupation of the general riverine niche after additional years, decades, centuries or millennia. If knowledge of the RP was lost, it could be re-created or re-evolve based on its clear advantages over nomadic hunting, known to both Neanderthals and AMH. Nomadic hunters also hunted in rivers in all probability. Abrupt climate change probably drove abandonment at multiple sites. The onset of warmer temperatures drove mammoth herds northward, and one of the last mega-sites was Berelekh, on the Arctic Ocean. (Shipman, 2014: Table 1).

Flooding and geomorphic change. Increased runoff associated with permafrost and other periglacial conditions may have produced Paleolithic floods with discharges up to eight times those of modern rivers (Sidorchuk et al., 2001). Such major floods could have substantially altered the riverine hunting system by eroding upstream paleo-fords and riverbanks, modifying mammoth movement patterns, widening or diverting paleochannels, and destroying or displacing fixed, labor-intensive structures within the river and killing zone. Sidorchuk et al. (2001) note that “[p]eriglacial river channels were formed under the conditions of high spring water flow,” suggesting that major channel-forming events may have coincided with the beginning of the spring mammoth-hunting season. Even relatively minor geomorphic changes could permanently eliminate low-water crossings and fords or alter paleo-ravines. Consequently, the hunting system was highly dependent on, and vulnerable to, changes in channel morphology, discharge, spring flooding, channel width and direction, vegetation, and the movements of mammoths seeking rivers over distances of several kilometers. Although some surviving mammoth-bone structures were sufficiently elevated to withstand major floods, lower riverine structures, crossings, fords, hunting terrain, vegetation, and entire killing zones may have been destroyed or substantially modified. A settlement dependent on a single productive ford could therefore have lost an important hunting location following a major flood. Extreme spring flooding may also have altered the crossing routes of mammoth, bison, horse, and reindeer herds, forcing hunters to operate before, during, or after peak discharge and potentially requiring the annual reconstruction or relocation of riverine hunting structures.

River volume decrease, tied to climate change, might have played a role. Droughts probably only had to last a year or two to initiate abandonment of sites.

Bands may have re-located to a more favorable site, perhaps on the same river or river system. One explanation for mega-site abandonment could be that controlling mammoth matriarchs and other game avoided heavily hunted paleo-fords and kilometers of river, changed migration routes or water consumption times, found water outside of those river segments, learned to ignore or avoid dogs, or left rivers promptly and generally learned better to avoid the risks of Paleolithic riverine hunting. Letting dogs run loose would better advertise risks for mammoths. The overhunted territory may have caused entire bands to find a less hunted or un-hunted stretch of river. Through multiple generations and population increase, multiple Mezinian mega-sites may have been occupied by essentially the same people, without radiocarbon dating being able to discover the differences in decades between site occupations. Operating two or three different settlements would lessen risks from the devastating impacts of high-energy flooding, changes in mammoth herd movements, over-hunting, and other risks.

Kraców-Spadzista per Wojtal, et al. (2025) was supposedly abandoned annually. Wojtal, et al. (2025) published taphonomic and statistical substantiation for the RP, and commentary is added, as follows:

The site is at the confluence of two rivers, typical of RP mega-sites. The mammoth bones were placed closest to the Rudawa River. Only whole (disarticulated) mammoth skeletons were found, and horse, wolf, and reindeer also arrived intact. At Kraców-Spadzista, excavators found 65,981 bone fragments with signs of burning (Wojtal et al., 2025), probably from smokehouses and hearths still buried, and no signs of roasting meat on bones was found. No mammoth skulls were found at Kraców Spadzista (Wojtal et al., 2025), which may have formed the foundations of smokehouses as in Mezinian MMBS.

Mammoth meat and fat required processing on site and then strongly imply sedentary activity thereafter. No clear reason or destination is given for the supposedly departing hunters, who would not want to take all their processed and stored food, bones, skulls, and ivory with them, and upstream hunting camps may explain any partial departure. MMBS could still be at the site or under modern structures in Kraców. Only 384/10,000 sq. meters have been excavated. Evidence of four (4) lithic points in *lateral rib bones* does not indicate mammoths were killed at the site but were assaulted in rivers over time probably with the use of poison. It is possible a large killing zone was erected across the relatively narrow Rudawa River near this site and the mammoths driven there by hunters or dogs. Wojtal, et al. (2025) may be confusing annual abandonment with partial movement of mammoth people upstream into warm-weather hunting camps.

Future Research. Advancements in digital photography, photometric stereo, photogrammetry, 3D modeling software, automated dome lighting, raking light, and related computer applications and techniques have significantly enhanced the technical capability to photograph faint or obscure lines on bone and ivory over the past decade. (Bornstein & Keep, 2023). Each ivory and bone process chart could benefit from large-scale optical magnification, appropriate lighting, and projection into two dimensions using modern computerized photography applications and equipment. Additionally, X-ray radiography and CT scanning could be employed to examine beneath smudge marks or surface defects. The identified

process charts may provide additional information not accurately captured by existing drawings. Other process charts on bone or ivory may still be concealed at Paleolithic archaeological sites or remain unidentified in artifact collections. Other proboscidean bone accumulations might be associated with Paleolithic rivers out of which they may have been killed.

Several aspects of the River Paradigm remain provisional. Direct archaeological evidence for specific riverine hunting structures is limited to the Předmostí Riverine Hunting Map Process Chart. The massive spear hypothesis might be tested by the construction of same, with lubricated fulcrum and distal support. Future field investigations focused on locating upstream warm-weather outposts, possible paleo-fords, paleochannels, river-margin features, and high-resolution spatial analyses may further test the model.

Whether the availability of abundant dog food enabled the domestication of dogs and invention of dogsleds by mammoth hunters remains an open research question. Whether sedentary habitation near frozen rivers gave rise to the invention of ice skates and dogsleds is similarly in need of evidence. The River Paradigm will hopefully bring about more scrutiny of bone, ivory, and lithic specimens in existing archaeological assemblages or new excavation in an identification search for process charts, riverine symbolism, ice skates, bone or ivory massive thrusting spear supports, and conceivably bone or ivory dogsled runners for use on river ice or the frozen ground.

Mammoth archaeology would benefit by additional translations, summaries, compilations, research, and indexing of, and access to, archaeological studies written exclusively in Russian and Ukrainian languages, which translation work might be accomplished through artificial intelligence.

12.0 Conclusion

The River Paradigm (RP) provides a framework for interpreting a wide range of unresolved questions concerning Upper Paleolithic mammoth procurement, processing, transport, and settlement. By shifting the analytical focus from predominantly terrestrial acquisition to riverine procurement, the RP offers explanations for observations that have remained difficult to reconcile within conventional hunting models. These include questions concerning whether mammoth-hunting communities were sedentary; whether mammoths were actively hunted or scavenged; the function of beveled ivory spear points; the abundance and distribution of burned bone fragments around mammoth-bone structures; the efficiency of the mammoth economy; the storage of meat and fat; sex ratios in anthropogenic mammoth-bone assemblages; the participation of females in mammoth hunting; the availability of mammoth-derived food for dogs and wolf-dog populations; and the identification and interpretation of engraved ivory objects proposed here as process charts.

The RP addresses several logistical and technological problems that have received comparatively limited attention. These include how assemblages containing the remains of numerous complete individual mammoths—represented by minimum numbers of individuals ranging from 1 to more than 100—could have accumulated at a single settlement; how mammoth carcasses or their component parts could have been transported efficiently; how hunters achieved safety during encounters with mammoths; why massive thrusting spears were likely advantageous; and how purpose-built killing zones could have been formed in riverine terrain. The paradigm further provides a framework for interpreting possible evidence of meat

smoking and fat rendering in mammoth-bone structures, the organization of labor and management during hunting and carcass processing, alternative hunting techniques used in conjunction with massive spears, and possible relationships between mammoth procurement and Paleolithic art.

The riverine framework generates broader explanations for several previously unresolved observations. These include possible geomorphic causes of settlement abandonment, changes in mammoth movements associated with river dynamics, the possibility of localized over-hunting, and the unusually destructive flooding that characterized some Late Pleistocene river systems receiving runoff from permafrost. Because most successful mammoth hunts occurred in rivers, conventional depictions of hunters confronting mammoths on open ground represent a persistent terrestrial bias rather than an accurate reconstruction of hunting.

The significance of the RP therefore lies not in any single proposed explanation but in its ability to integrate archaeological, taphonomic, ecological, technological, manufacturing process, and logistical observations within a common model. Some elements of the paradigm are interpretations of existing evidence, while others remain hypotheses requiring independent testing. The central proposition is that riverine procurement provides a more comprehensive explanatory framework for the available evidence than the long-standing assumption that mammoths at major Upper Paleolithic settlements were acquired primarily through terrestrial hunting. Rather than replacing individual lines of evidence, the RP seeks to connect them within a coherent procurement system encompassing site location, hunting, carcass recovery, river transport, processing, storage, and settlement use.

Under this framework, observations that appear anomalous or difficult to explain under a terrestrial acquisition model become more explicable consequences of a river-based system. The RP consequently expands the range of testable hypotheses concerning mammoth hunting technology, settlement organization, labor, food preservation, transportation, hunter safety, and the relationship between mammoth procurement and Paleolithic culture.

The River Paradigm (RP) probably started when early mammoth hunters in nomadic hunting bands of different sub-species, possibly *Homo erectus* and definitely *Homo neanderthalensis* and *Homo sapiens*, discovered it was easier and safer to kill alert mammoths in rivers (or in ponds or lakes) than on open ground and that mammoth carcasses were then only movable by river. The RP developed naturally from terrain, herds of mammoths, long-standing fire technology in food preservation, the utilitarian value of all mammoth tissues, and the force multipliers of reversing tactical elevation and pre-positioned massive thrusting spears. Due to manifold advantages, the RP was probably re-discovered or re-used many times, especially after cultural memory was lost in whole or in part by prohibitive climate, the passage of millennia, subsistence changes, or migration patterns.

The Tactical Reversal Schedule goes a long way towards establishing the benefits of riverine hunting and disproving terrestrial hunting relative to large bone accumulations. The profound reversal of nearly every advantage and disadvantage for both species explains the RP in practical terms.

As a production line, the MNI for mammoths substantiated effectiveness and efficiency in output, the production of smoked or dried meat packages, pemmican, or stored rendered fat, and in addition building materials and a wealth of useful objects. The analyzed cultures were dynamic both physically—

through killing zones, river transport and processing of carcasses—and culturally, as shown by their high achievements and exceptional artifacts.

The River Paradigm (RP) is a cogent and corroborated explanation of an entire Upper Paleolithic mammoth procurement and utilization *system.* That system reversed the relative disadvantages of 67 kg humans vis-à-vis 3,000 to 6,000 to 8,000 kg mammoths. After a century, no other definitive explanations of the MMBS, largest bone accumulations, taphonomic representation of entire mammoths in MMBS settlements, or efficient killing and transportation have been made. The RP offers a parsimonious explanation consistent with a convergence of archaeological, taphonomic, geographic, and iconographic evidence. Previous thoughts expressed in scientific literature concerning terrestrial acquisition were always tentative and incomplete. The RP reduces the explanatory necessity of scavenging-based and bone-collecting models, *in situ* killing of herds, and terrestrial procurement, because it provides an alternative and explicable mechanism for more efficiently acquiring large numbers of mammoths and other large prey animals.

The many efficiencies and production line aspects of the River Paradigm (RP) contrast starkly with the relative poverty of nomadic and terrestrial hunting. Hunting, living, processing, and storage structures were site and capital improvements to the land made by very productive people. We should move successful mammoth hunters out of the ranks of scavengers and nomads and place them squarely within the ranks of skillful early sedentary cultures, for which there is abundant material evidence in artifacts, dwellings, tools, construction of elaborate killing zones, elevated meat/fat caches, use of hunting dogs, production of food, clothes, shelter, and art, and the five process charts. Upper Paleolithic AMH mammoth hunters and Middle Paleolithic Neanderthals have been underestimated, portrayed as unsuccessful hunters, and mischaracterized far more than their accomplishments justify.

Iakovleva (2016) observed that the "palaeoeconomy of the Mezinian is based on intensive and systematic mammoth exploitation." Their successful system was the River Paradigm (RP), harvesting large numbers of mammoths. Mezinian mammoth people were relatively well-dressed (Iakovleva, 2016) and took large numbers of fur-bearers (Soffer, 1985:400). Soffer found that the number of wolves taken in the Middle Dnieper River Basin exceeded the utilitarian needs of those sites. (Soffer, 1985:320).

What facts, inferences, theories, or hypotheses are proposed by the RP, a model of riverine mammoth procurement and processing?

- The five process charts, taphonomic data, and allied evidence display overtly and through necessary inferences the RP, which operated productively through the five phases of the mammoth palaeoeconomy and in multiple mammoth-hunting cultures.
- MMBS people were sedentary, as shown by solid MMBS, elevated meat/fat caches, the elaborate Předmostí constructed killing zone, the necessity of riverine siting, and overall prosperity.
- Regarding mammoth-bone structures and large accumulations of mammoth bones at mega-sites, residual doubts about whether mammoths were hunted should be clarified and resolved in favor of active hunting procurement.
- Mammoth-hunting territories or catchments were the kilometers of river terrain above settlements, which could be shaped and constructed to maximize mammoth acquisition, and within which hunters from the MMBS settlement set up temporary warm weather hunting outposts and killing zones.

- The RP and its hunting methods minimized or eliminated unsafe close-contact hunting of mammoths and maximized tactical elevation and associated advantages for hunters.
- Sedentary mammoth hunters prepared one or more river segments to keep mammoths in the river and trap, wound, and kill mammoths with structures, channeling, hunting positions, massive spears, impalement, projectiles, other weapons, and barriers.
- Scavenging and bone collecting by sedentary mammoth hunters were negligible compared to the productivity of the MMBS communities and the emphasis on nutrition and organic resources.
- Classification of sites into “kill sites” or “fast-access scavenging” sites is no longer valid because those sites never existed, but all MMBS sites were “butchery sites” and the killing sites were in rivers.
- The RP upholds the major dietary importance of fat and meat to MMBS peoples.
- Constructed traps (killing zones), not natural traps, explain acquisition of mammoths better than natural theories. (Cf. Svoboda et al., 2005)
- Bone beds in settlements resulted from anthropic activity.
- Pre-positioned massive thrusting spears were the main Upper Paleolithic weapons that killed mammoths in rivers, possessing (a) reliable killing power, (b) safety, (c) survival value as to food, materials, and safe operation, (d) pre-positioning, (e) use of multiple spears against one mammoth, (f) extra power imparted by multiple hunters and incline angle of thrusting spear, and (g) lubrication.

By 40,000 years ago, European mammoth hunters had flutes made from bird bones and mammoth tusks. Later, they built a mammoth bone orchestra. Mammoth hunters in Central Europe created the first known ceramic objects while those in Eastern Europe built the first documented elevated meat/fat caches. Mammoth hunters created the first known process charts and probably early management authority symbols. Sedentary mammoth hunters centralized meat processing, utilizing highly efficient water power in their riverine slaughterhouse and to transport carcasses. These cultures operated wholly and vertically integrated production systems using water power. Within science, the River Paradigm is the first complete mammoth procurement and utilization system substantiated with credible evidence of hunting structures and procurement, transportation of carcasses, butchery, tissue processing, and elevated storage of processed fat and meat.

Molodovan Mousterian Neanderthal, Pavlovian, and Mezinian Cultures were among the earliest sedentary peoples in the world, preceding the Natufians. Organized sedentary mammoth hunters were pioneers in the production of warm fur clothing, the eyed needle, and woven cloth. (Gilligan et al., 2024; Gilligan, 2010). Long before Göbekli Tepe was built in Turkey, mammoth hunters pioneered architecture by designing solid, insulated multi-purpose buildings with clever inclusion and use of mammoth skulls, bones, mandibles, tusks, hides, and loess. They employed a precise northwest-southeast orientation to catch sunlight both in the morning and afternoon.

It has been said that “there are no eyewitness accounts of the distant past” (Haynes, 1991:259), but the discussed process charts are memorialized eyewitness accounts, illustrating mundane features of productive culture in Paleolithic blueprints. Paleolithic hunters illustrated on ivory and bone what they saw: mammoth carcasses in rivers tied up below mega-sites, a flap of thick mammoth hide and subcutaneous fat held back by cords to provide initial butchery access, loose bones and tusks from butchery, paths and steps from rivers up to settlements of MMBS, structures of different types, and to the

author's interpretation, dog kennels, raw and smoked meat packages at Mezhyrich, and curved ivory tusks serving to support elevated meat/fat caches both horizontally and vertically. The Předmostí Chart provides a picture window into the lethality of riverine mammoth hunting and the best evidence of how mammoths were routinely harvested. Mammoth people recorded their subsistence system on ivory and in one case bone, and their depictions agree with the terrain, physical facts, logistics, data, artifacts, needs of Paleolithic people in an Ice Age, and dynamic processes. Process charts spanning some 26,000 years and three cultures separated by millennia and distance demonstrate a cyclical human response to recurring environmental conditions.

Prehistory is the time before written records. The five charts are written records, documents, pictographic illustrations of mundane objects and processes, Paleolithic blueprints. The five charts may represent some of the oldest pictographic writing systems and some of the oldest written records, predating cuneiform, the Kish Tablet, and Egyptian hieroglyphs by multiple millennia. The five charts may represent the literal dawn of history. They inform us how mammoth hunters over three cultures and two different races flourished under a common River Paradigm. While the general importance of Upper Paleolithic river systems has been recognized and discussed in terms of AMH expansion in Europe, communication and trade (Hussian & Floss, 2016), the action and basic resource acquisition possibilities through the RP determined the lifeways and culture for organized mammoth hunters.

The five process charts provide evidence of the longest-lasting though not continuous successful highly organized subsistence system. This evolving system was based on tremendous riverine hunting advantages, standardization of the five phases of the mammoth palaeoeconomy, water power, pyrotechnology, MMBS, hunting dogs in the Mezinian and Pavlovian Cultures, killing zones built in rivers, meat and lipid processing, advanced hunting weapon technology, possibly poison, and elevated food storage. The model was employed in Central and Eastern Europe, starting with Neanderthals at Molodova I-Layer 4 before 44,000 years ago (Demay et al., 2012) and continuing for at least 26,000 years, climate, flooding, mammoth herd locations, and unknown factors permitting.

Sedentary mammoth hunters fit neither the typical nomadic style of subsistence nor the agriculturist sedentary mode. Instead, they pursued a distinct and advanced mode of subsistence conforming to the River Paradigm. Their nonconformance with both the predominant hunter-gatherer and sedentary agriculturalist profiles made them more difficult to understand and appreciate.

Molodovan Mousterian Neanderthal Culture, Gravettian Pavlovian Culture in Moravia, and Epigravettian Mezinian Culture in the Middle Dnieper River Basin created prosperity, sturdy warm multi-purpose structures, clothing, tools, containers, a standardized routine production process, art, and various advancements. Their ability to produce and maintain an abundant food supply demonstrates a high level of resourcefulness and planning. The same can be said of Northern Eurasian mega-sites.

The Mezinian settlement inhabitants in the Middle Dnieper River Basin and Kostenki-Borschevo sites were socially complex sedentary hunter-gatherers between 19,000 and 17,500 cal BP. Mezinian Culture displayed impressive technology and refinement in adornment as described by Iakovleva (2016), supported by the great number of woolly mammoths they harvested. Mezinian MMBS were the first to use mammoth skulls for their foundations (Iakovleva et al., 2012). Organized riverine mammoth hunters were

producers, builders, innovators, manufacturers, likely traders and the most advanced hunter-gatherers. If we look carefully, we detect the earliest signs of modernity.

The River Paradigm (RP) offers a unified explanatory framework for addressing long-standing questions concerning mammoth procurement, transport, processing, and the function of MMBS settlements. While aspects of the model remain open to further testing, it integrates a broad range of archaeological observations that have previously been treated separately and provides a series of testable predictions for future research. Within the vicissitudes of Ice Age climate, organized mammoth hunters in Central and Eastern Europe were the most advanced people with the highest productive cultures during their times to live.

Errata. GLEISSNER, J.D., 2025. Explaining the Mammoth Economy, Smokehouses, and the Mezhyrich Map. *Glob J Arch & Anthropol*. 2025: 14(3): 555888. DOI: 10.19080/GJAA.2025.14.555888, mentioned 70 MMBS sites, and that should have been about 70 individual MMBS and far fewer mega-sites. An individual settlement of mammoth hunters should not have been referred to as a technocomplex.

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