



Reassessing the Evidence for the Composite Bow in Ancient Eurasia

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Abstract

Prevailing theories suggest that the composite bow originated in the fourth millennium BCE and developed independently in multiple regions. However, these claims often rest on insufficiently analyzed evidence and inconsistent definitions of what constitutes a composite bow. This paper reassesses the origins and development of the full—horn—wood—sinew—composite bow by integrating iconographic and material data, framed within broader archaeological context and supplemented by genetic evidence on human population history. It argues that the supposed Early and Middle Bronze Age examples of composite bows are better understood as double-convex self bows, implying that (1) the full composite bow was a Late Bronze Age innovation, likely emerging in the first half of the second millennium BCE, and that (2) this technology originated only once—probably in the Near East—and spread rapidly across Eurasia, mirroring the diffusion patterns of other major innovations, such as domestic horse, the spoke-wheeled chariot, and horseback riding. The paper also challenges the assumption that early Indo-European groups used composite bows, finding no compelling evidence to support this claim. Instead, it identifies the Indo-Iranians as key agents in the transmission and further development of composite bow technology, culminating in the emergence of the distinctive *Scythian* design by the fourth century BCE. While these findings clarify important aspects of the composite bow history, many questions remain. Future research incorporating philological, linguistic, and quantitative methods—especially cultural phylogenetics—holds significant potential for deepening our understanding of the bow-and-arrow technology.

Keywords Bow-and-arrow · Bronze Age · Composite bow · Double-convex bow · Eurasia · Indo-European

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Introduction

The bow-and-arrow stands as one of humanity's most important technological innovations, representing the earliest projectile system capable of storing energy (Grayson *et al.*, 2007). Yet, reconstructing its full history remains challenging due to the poor preservation of organic materials, leaving only partial narratives to be put together. This review examines one such narrative—the origin and spread of the composite bow.

In contrast to a self bow, which is made from a single material, *i.e.*, wood, a composite bow features multiple materials (Fig. 1). It is important to note that the term *composite* is used broadly in the literature to describe any bow that combines multiple materials, even in the non-working sections. Here, *composite* refers specifically to bows whose limbs—sections under the greatest stress—are constructed from a full composite of a wooden core, horn plates on the inner side (facing the archer), and a layer of sinew on the outer side (facing away from the archer), with all parts joined using glue (Fig. 1). Sinew, compared to wood, is about four times more resistant to tensile stress, while horn can withstand twice as much compression and has a high capacity for elastic recovery (Bergman *et al.*, 1988; McEwen *et al.*, 1991). These properties allow composite bows to be shorter and lighter than wooden self bows, without compromising their draw length. The light, highly flexible, and reflexed limbs of the composite bow store more potential energy and are more efficient in transferring this energy to the arrow (as kinetic energy) than the self bow (Bergman *et al.*, 1988; Klopsteg, 1947). As a result, arrows fired from the composite bow possess greater kinetic energy compared to those fired from the self bow of equal draw weight. Alternatively, this energy advantage can be leveraged for heavier arrows, enhancing penetration potential (Miller *et al.*, 1986). Composite bows also have a practical advantage of remaining strung for extended periods, such as during military campaigns, without losing power (Klopsteg, 1947). The technological and military dominance of composite bows persisted for several millennia until firearms, achieving comparable performance only by the mid-nineteenth century CE, rendered them obsolete (Denny, 2011; Hurley, 2011; Nieminen, 2011).

Despite its historical significance, questions regarding the place and time of the composite bow origin remain. Existing interpretations commonly suffer from superficial analysis and insufficient scrutiny of prior claims. Moreover, researchers rarely draw on broader archaeological and historical contexts for more robust inferences. By integrating iconographic and material evidence with data on human population history, this review critically revisits the current state of knowledge on the composite bow origin and diffusion. It also incorporates lesser-known findings from non-English sources to provide a more comprehensive perspective.

Contrary to previous assumptions, this paper contends that the composite bow was a later innovation that originated only once, likely in the first half of the second millennium BCE in the Near East or the Volga–Ural steppes, and then rapidly spread across Eurasia, with Indo–Iranian cultural groups of the Eurasian steppes playing an instrumental role in spreading and advancing this technology across the continent in subsequent centuries.

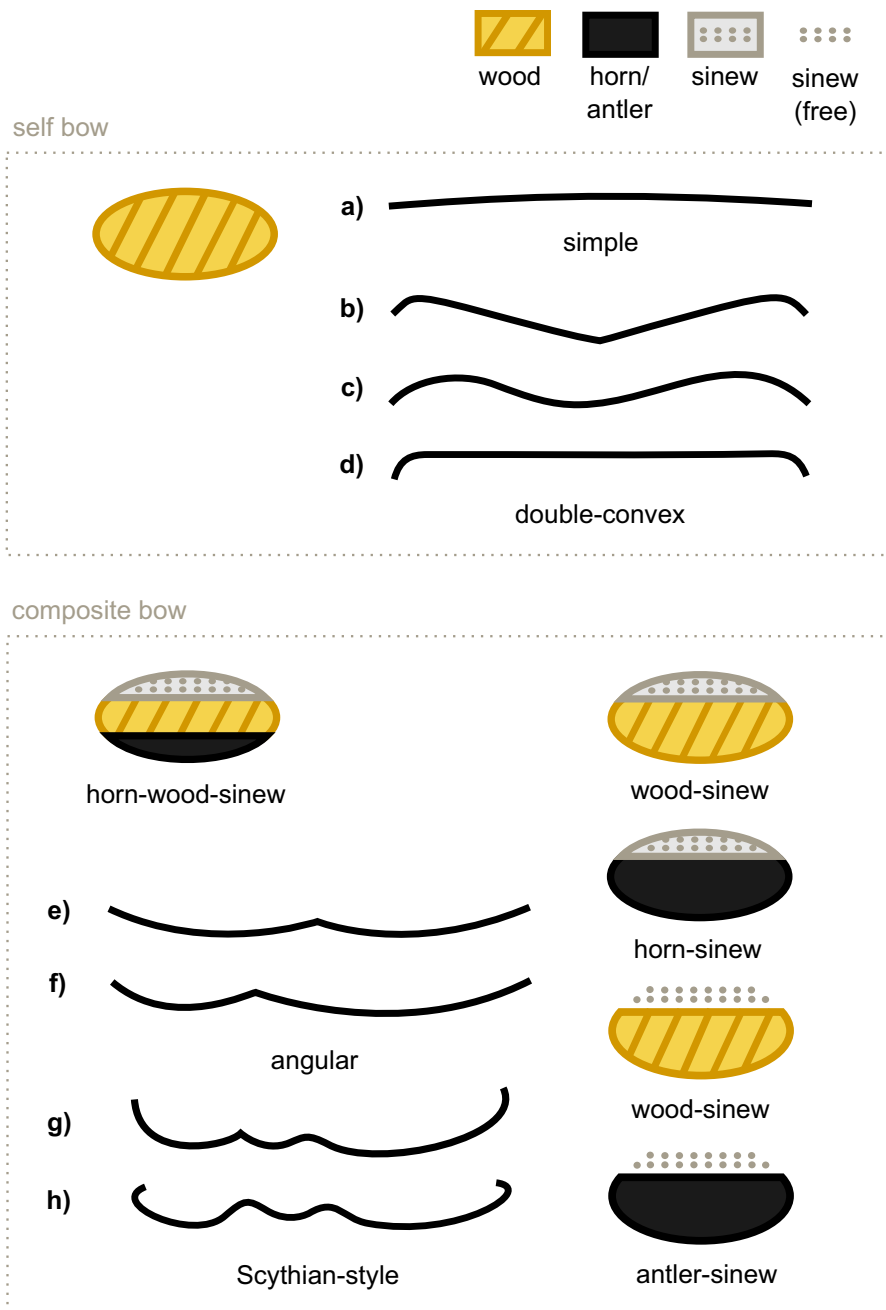


Fig. 1 Schematic representations of the main bow types discussed in the text. Cross-sections illustrate the mid-limb region, while the bow profiles show unstrung bows in lateral view, with the outer side facing upward

Revisiting the Hypotheses About the Place of the Composite Bow Origin

An integral aspect of the debate concerning the place of the composite bow origin is whether it was developed only once, and subsequently spread to other regions, or emerged independently in multiple areas. The *multiple-origins* hypothesis posits that the composite bow arose wherever environmental conditions required the use of non-wood materials—for example, in treeless tundra or steppe environments (Pitt-Rivers, 1877; Balfour, 1890; Clark, 1963; Miller *et al.*, 1986; McEwen *et al.*, 1991). Examples commonly cited as evidence of such independent evolution include the bows of the Great Plains and Pacific Coast of North America (*e.g.*, Hamilton, 1970; McEwen *et al.*, 1991). However, these bows do not exhibit the *full* horn–wood–sinew structure but rather *partial* composite construction—combining only two materials, such as wood–sinew or horn–sinew (Fig. 1).

Although both full and partial composite bows are technically *composite* (Fig. 1), grouping them into a single category in studies of the composite bow origin is problematic for several reasons. Firstly, recent scholarship indicates that partial composite bow technology in North America was an Asian import, likely introduced during the late first or early second millennium CE and spreading southward with the Athabascan expansion (LeBlanc, 1998; Wilson, 2023). Secondly, partial composite bows in Eastern Siberia and North America appear to be derivatives of the full composite bow. Some scholars have suggested that partial composite bows, such as wood–sinew or antler–sinew bows used by the Inuit, are basal lineages closely related to a regional ancestral prototype from which the full composite bow evolved (Pitt-Rivers, 1877; Balfour, 1890). These bows are characterized by sinew cords laced along the bow's outer surface, typically without glue (Murdoch, 1884; Pfeifer, 2021; Fig. 1). While the full composite bow must have evolved from an earlier, yet unattested, partial composite form, the earliest evidence of this *free-sinew* technology—namely bracers and twisters—comes from Punuk culture sites dated to the late first millennium CE (Collins, 1937; Ford, 1959). This is over two millennia later than the oldest evidence for full composite bows (discussed below). The sudden appearance of this technology at Punuk sites—alongside other military innovations, such as plate armor and wrist guards—suggests that it was introduced from elsewhere, likely Manchuria or eastern Mongolia (Collins, 1937; Mason, 2016). This type of partial composite bow spread as far as the southwestern United States where it was used by the Apache, a branch of Athabascan speakers (Gifford, 1940; Wilson, 2023). Furthermore, the bows of the Inuit, Chukchi, and Koryak populations exhibit features that appeared in composite bows only after the second millennium CE, *e.g.*, V-splice joints or string bridges, indicating continued influence from the steppes (Ford, 1959; Lepola, 2015; Pfeifer, 2021). These lines of evidence suggest that partial composite bows in Eastern Siberia and North America arose through horizontal transmission, rather than independent evolution. Moreover, they should not be regarded as relics, but as simplified modifications of the full composite bow (Hamilton, 1970; in the ensuing text, the word *composite* refers to the full composite unless otherwise stated).

Despite this, Siberia has yielded what is often considered the earliest direct evidence for composite bow—namely, antler rods recovered from late Neolithic Serovo

culture sites (ca. 3000 BCE) in the Cis–Baikal region (Okladnikov, 1950). Similar finds come from the Krasny Yar site of the Early Bronze Age Okunevo culture in the Altai–Sayan region (Vadetskaya, 1981). The Serovo rods—found in male, female, and child burials—had a flat-convex cross section with longitudinal grooves on the inner face. They were unusually thin (maximum width 1.4–1.5 cm), straight, and showed no evidence of reflex. The distal ends tapered along the inner surface to form a 10–15 cm overlap, producing a continuous stave between 1.05 and 1.69 m in length (Supplementary Fig. 1). With a single exception, the rods lacked string nocks, and Okladnikov only speculated—without direct evidence—that glue may have been used. If these rods were indeed parts of bows, they likely would have been joined with another component, *e.g.*, a wooden lath, to form a functional implement. However, their overall characteristics and the absence of further details render them inconclusive as evidence for full composite bows. At best, they may represent early experiments in reinforcing bow limbs with non-wood materials.

Given an apparent simplicity of the idea that the composite bow was developed in environments lacking quality bow wood, *e.g.*, steppe, some scholars have linked its emergence to other cultural innovations, particularly the domestic horse and the advent of horseback riding. This refined *steppe-origin* hypothesis proposes that the composite bow was intentionally developed to meet the demands of mounted warfare—namely, the need for a short, powerful weapon effective from horseback (*e.g.*, Balfour, 1890; Miller *et al.*, 1986; McEwen *et al.*, 1991; Shishlina, 1997). An implicit assumption of the *steppe-origin* hypothesis is that, prior to the invention of the composite bow, the self bow was used in mounted warfare (*e.g.*, Anthony & Brown, 2011). However, these views have been complicated by recent developments in archaeological and genetic research on horse domestication.

The earliest presumed evidence for horseback riding comes from the Botai culture in the northern Kazakh steppe (ca. 3500 BCE; Outram *et al.*, 2009; Anthony & Brown, 2011), or later from Yamnaya pastoralists of southeastern Europe (ca. 3000 BCE; Trautmann *et al.*, 2023). However, the interpretation of this evidence remains contested (see Taylor and Barrón-Ortiz, 2021; Hosek *et al.*, 2024). Recent studies combining ancient horse genomes and archaeological data suggest that widespread use of horses for transport, including riding, did not occur until ca. 2200 BCE (Drews, 2004; Librado *et al.*, 2021, 2024). This corresponds with the spread of a genetically distinct horse lineage—DOM2—originating in the lower Volga–Don region, which rapidly proliferated across Eurasia and became the ancestor of all modern domestic horses (*Equus caballus*; Librado *et al.*, 2021). The first appearance of DOM2 horses in the Near East coincides with the earliest iconographic depictions of riders ca. 2000 BCE (Drews, 2004; Librado *et al.*, 2021). However, these early forms of riding were not suited for mounted combat (Drews, 2004). Riders depicted in Near Eastern imagery from this period carry no bows or other military gear.

More compelling archaeological evidence for horseback riding—linked to a major cultural shift in the domestic horse use—only appears in the Late Bronze Age (ca. 1200 BCE) steppes of East Asia (Taylor & Tuvshinjargal, 2018; Taylor *et al.*, 2017, 2020). Horseback archery, adopted as a widespread military practice, emerges shortly thereafter in the Early Iron Age (Anthony & Brown, 2011; Cunliffe, 2019; Drews, 2004). However, the earliest physical evidence of the composite bow

predates horseback archery by approximately 500 years and follows the emergence of DOM2 horses by a similar margin, making any causal connections implausible.

Comparisons to the North American Great Plains—where a partial composite bow (horn–sinew; Fig. 1) emerged in the eighteenth century CE with the introduction of the domestic horse (*e.g.* Hamilton, 1970; McEwen *et al.*, 1991)—can be misleading. The horses introduced to North America had already been adapted for riding, and the horn–sinew bow does not represent a *de novo* invention of composite technology; rather, similar forms of partial composite bows had been used in the region for centuries (Gifford, 1940; Mitchell, 2015; Wilson, 2023). Taken together, there is not only a lack of firm evidence for mounted warfare—including the use of self bows—in association with early riding, but also no direct link between the origin of the composite bow and the emergence of horseback archery.

Nonetheless, one steppe-related innovation more closely coinciding with the composite bow origin is the spoke-wheeled chariot. The earliest examples of light, horse-drawn chariots with spoked wheels were developed by the Sintashta culture ca. 2000 BCE in the southern Trans–Ural region (Lindner, 2020; Kuznetsov, 2006). The DOM2 genetic profile was widespread among Sintashta horses, and both horses and chariots spread rapidly across Eurasia—reaching Anatolia by ca. 1900 BCE and East Asia by ca. 1500 BCE (Drews, 2004; Honeychurch *et al.*, 2025; Librado *et al.*, 2021; Moorey, 1986). By the New Kingdom period, the chariot along with the composite bow was firmly integrated into Egyptian military practice (Genz, 2013). Although early chariot iconography in the Near East rarely depicted archery—with a few poorly preserved representations of bows on some Syrian seals (Littauer & Crouwel, 1979; Moorey, 1986)—in both Egypt and East Asia, horses, chariots, and the composite bow appeared together as part of a functional military complex, which also included metal arrowheads and scale armor (Genz, 2013; Honeychurch *et al.*, 2025; Moorey, 1986). Thus, regardless of whether the chariot played a direct role in its invention, the composite bow likely emerged within this early geographic range of chariot use—that is, across the region spanning Anatolia and Syria to the Volga–Ural steppes—indicating that the *steppe-origin* hypothesis cannot be entirely dismissed. Although the evidence reviewed above suggests that horse domestication, horseback riding, and probably the chariot were not causally linked to the origin of the composite bow, these key Bronze Age innovations played a crucial role in its subsequent spread.

Finally, the oldest securely dated composite bows come from the Theban necropolis in Egypt, dating to the early New Kingdom (ca. 1600 BCE), with most specimens recovered from the tomb of Tutankhamun (ca. 1300 BCE; McLeod, 1962, 1970). The most recent ancient Egyptian specimens date to ca. 700 BCE (Balfour, 1897; McLeod, 1958). However, these so-called *angular* bows, characterized by their inward bend at the grip when unstrung (Fig. 1e), were not indigenous to Egypt. They appear to have been introduced during the late Second Intermediate Period, when Egypt was occupied by the Hyksos, a Semitic people from the northern Levant (Bietak, 2019; Genz, 2013; Mourad, 2015). Many Egyptian angular bows were made of ash and covered with birch bark, suggesting that either the raw materials or complete bows were imported from northern regions. Some angular bows may have been spoils of war from the Hittites or Assyrians (Balfour, 1897; McLeod, 1958;

Rausing, 1967). Inscriptions from a Theban tomb at Qurna suggest that at least one of these bows was owned by a man of Syrian origin (Brunton, 1938).

Taken together, the evidence suggests that the Near East—particularly Syria, Anatolia, or northern Mesopotamia—was the likely source of the full composite bow technology that entered Egypt no later than ca. 1600 BCE. However, scholarly opinions diverge considerably on the precise time of its emergence in the Near East. While both iconographic and material evidence from Egypt allow for cross-validation, in western Asia, the record is limited to iconography, which is often overinterpreted, leading to exaggerated conclusions about the antiquity of the composite bow.

Revisiting the Hypotheses About the Time of the Composite Bow Origin

The earliest iconographic depictions commonly interpreted as composite bows date to the late Eneolithic/Early Bronze Age, specifically the Late Uruk and Susa II periods (ca. 3300 BCE) in Mesopotamia and Elam (*e.g.*, Rausing, 1967; Zutterman, 2003; Randall, 2016; Álvarez-Mon, 2023). These bows are described as double-concave with strongly recurved tips, sometimes with a set-back grip. Notably, some seals from Chogha Mish in Elam depict bows with what seem to be angular grips (Fig. 2a; see also Delougaz & Kantor, 1996; Álvarez-Mon, 2023). Strikingly similar bow depictions appear in iconographic material from diverse regions: the Maykop–Novosvobodnaya stone slab from Klady in the North Caucasus, the Mykhailivka/Yamnaya stele from Natalivka in Ukraine, and the Göhlitsch stone slab from Germany, associated with the Bernburg culture (Fig. 2b–d). These sites are all dated to the late fourth millennium BCE (Bratchenko, 1989; Junkmanns, 2013; Klochko, 2001; Shishlina, 1997; Wang *et al.*, 2019).

This widespread distribution of similar bow imagery is unlikely to be coincidental. Instead, it reflects an extensive network of cultural and technological exchange spanning the Near East, the Caucasus, the Pontic–Caspian steppes, and Central Europe. Both archaeological and genetic evidence corroborate the existence of these interconnections (Belinskij *et al.*, 2017; Ghalichi *et al.*, 2024; Hansen, 2010, 2021; Skourtanioti *et al.*, 2020; Szmyt, 2013, 2014; Wang *et al.*, 2019). During the fourth and third millennia BCE, several transformative innovations emerged and rapidly spread across these regions, including wheeled transport, copper alloys, and woolly sheep. These developments were accompanied by profound social changes, such as increased social stratification and wealth hierarchies (Belinskij *et al.*, 2017; Hansen, 2010, 2021). These innovations—known as the Secondary Products Revolution (Sherratt, 1981, 1983)—originated in the Near East and radiated outward, particularly via the Caucasus.

Within this vibrant cultural and technological context, it is reasonable to posit that composite bow technology also emerged. This view has been widely accepted and reiterated by scholars over the past half-century (*e.g.*, Clark, 1963; Rausing, 1967; Kosko & Klochko, 1987; Bergman *et al.*, 1988; Bratchenko, 1989; Gimbutas, 1991; Shishlina, 1997; Rezepkin, 2000; Christensen, 2004; Junkmanns, 2013; Schunke, 2013; Wang *et al.*, 2019). However, there is a critical flaw in this narrative. While the stylistic consistency of bow depictions across these regions suggests that

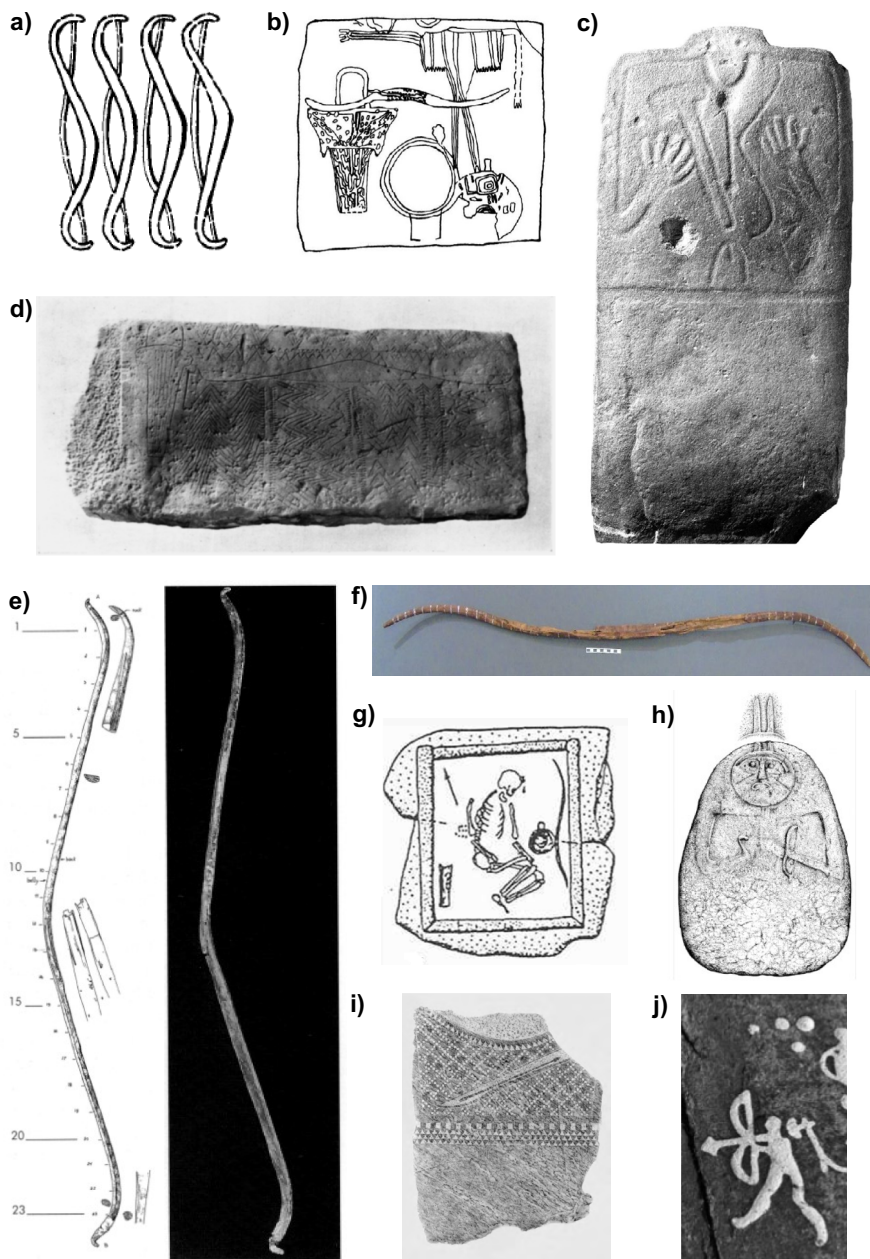


Fig. 2 Iconographic and material evidence of double-convex bows of the Early and Middle Bronze Age from various regions of Eurasia. **a** Chogha Mish, Iran (from Delougaz & Kantor, 1996). **b** Maykop–Novosvobodnaya, Russia (from Shishlina, 1997). **c** Natalivka, Ukraine (from Vierzig, 2020). **d** Göhlitsch, Germany (from Clark, 1963). **e** el-Makkukh, Palestine (from McEwen, 1998). **f** Sedment, Egypt (from Cook, 2018). **g** Hostra Mohila, Ukraine (from Klochko, 2001). **h** Yagshiin Khodoo 3, Mongolia (from Kubarev, 2012). **i** Petit-Chasseur, Switzerland (from Corboud, 2009); **j** Bohuslän, Sweden (from Skoglund *et al.*, 2022)

bow-and-arrow technology was a shared cultural element, the physical bows that served as models for these depictions were almost certainly not composite—neither full, nor partial. They were self bows.

In 1993, a cave burial was excavated in Wadi el-Makkukh near modern-day Jericho. Among the grave goods accompanying a male skeleton was a bow, broken in antiquity into two pieces (McEwen, 1998). The fragments could be fitted well, allowing for a reconstruction of the original shape. The bow featured a possible groove for hanging the string at one tip and small recurved hooks at both tips. Combined with its flat-convex cross section—typical for ancient bows—this indicates that the el-Makkukh bow was double-convex, with a deep reflex at the grip and sharply decurved tips pointing toward the archer (Figs. 1b and 2e). Crucially, it was made from a single piece of olive wood (*Olea europaea*). Radiocarbon dating placed the burial to ca. 3800 BCE (Jull, 1998).

Based on its funerary context—evidenced by the intentional breaking of the bow and its placement beneath the body—and the unusual presence of an archery set in the southern Levant at the time, it has been suggested that the individual buried was of foreign, likely northern Mesopotamian, origin (Bowden, 2024). This type of double-convex bow closely resembles the bow depicted on Halaf pottery from the mid-fifth millennium BCE site of Arpachiyah, Iraq (Supplementary Fig. 2), supporting the hypothesis of a northern Mesopotamian origin for the el-Makkukh bow. While earlier interpretations of the Arpachiyah bow suggested it might be composite (Colon, 1983) or questioned whether it was a bow at all (Randall, 2016), the el-Makkukh bow supports its identification as a double-convex self bow. This is also the design depicted on multiple Elamite seals from Chogha Mish and Susa mentioned above.

Further evidence for the double-convex design on these seals lies in the way the bows are held—with limbs projecting away and tips curving toward the archer (Supplementary Fig. 3). These features, previously misidentified as composite bows held frontally (Álvarez-Mon, 2023), align with the profile of the el-Makkukh bow. Moreover, the el-Makkukh bow's profile matches also those of Natalivka and Göhlitsch (Fig. 2c, d). The apparent confusion about these bows being composite stems from their extremely low brace height (the distance between the string and the inner grip). A deeply reflexed grip, like that of the el-Makkukh bow, combined with a slightly loosened string, as seen on some Chogha Mish seals (Fig. 2a), could create a *negative* brace height, giving the illusion of an angular composite bow. In other words, imagining a straight string stretched between the tips of the el-Makkukh bow produces a silhouette strikingly similar to the bows from Göhlitsch and Natalivka.

Northern Mesopotamia exerted significant cultural influence on the Caucasus since at least the late Neolithic (ca. 6000 BCE), when food production first reached the southern Caucasian slopes (Kohl & Trifonov, 2014; Skourtanioti *et al.*, 2020; Wang *et al.*, 2019). Early Eneolithic sites in the southern Caucasus exhibit parallels in architecture and ceramics with Halaf traditions from Mesopotamia (Badalyan *et al.*, 2010; Lyonnet, 2014). During the Uruk period in the fourth millennium BCE, Mesopotamian influence intensified, culminating in the emergence of the Maykop culture in the northern Caucasus, often considered the northwestern extension of the *Uruk expansion* (Frangipane, 2015; Pitskhelauri,

2012; Wang *et al.*, 2019). Genetic evidence shows that the Maykop population descended from a mix of local Neolithic inhabitants—comprising Caucasian hunter-gatherers as well as Anatolian/Iranian farmers (Ghalichi *et al.*, 2024; Wang *et al.*, 2019). These processes likely facilitated the transmission of the double-convex bow from Mesopotamia to the Caucasus, as seen in the Maykop–Novosvobodnaya stone slab from Klady.

In addition to the widespread depictions of double-convex bows, a number of contemporaneous seals from Mesopotamia and Elam indeed appear to show bows with a double-concave profile, characterized by recurved tips and, in some cases, a set-back grip. Notable examples include the Priest-King steles from Uruk and Susa. These bows have also been interpreted as early representations of composite bows (Rausing, 1967; Randall, 2016; Álvarez-Mon, 2023). However, unlike the more broadly distributed double-convex self bow of the time, or angular composite bow of later periods, such designs seem to have been geographically restricted to southern Mesopotamia and lack continuity in the archaeological record. This suggests that the bows depicted on the Priest-King steles were likely local variants of self bows, rather than full composite bows. Supporting this interpretation is the depiction of transverse arrowheads on the steles, a feature commonly associated with self bow use in the ancient Near East.

The oldest evidence of the double-convex design can be found on the preNeolithic (ca. 8000 BCE) rock carvings at Shywaymis in Saudi Arabia (Supplementary Fig. 4). Thus, the double-convex self bow has been present in the Near East as early as the pre-Neolithic, circulating widely across the region and, more than other bow types, extending through the Caucasus into the steppes.

Notably, the bow depicted on the Maykop–Novosvobodnaya stone slab (Fig. 2b) differs slightly from those at Natalivka and Göhlitsch (Fig. 2c, d), with its curves appearing less aggressive and more evenly distributed throughout the limb. Despite these differences, its profile strongly supports its identification as a double-convex self bow (Fig. 1c). Close parallels to the Maykop–Novosvobodnaya bow are found in ancient Egyptian art, for example, in the tomb of Khnumhotep II at Beni Hasan ca. 1900 BCE (Kamrin, 2009). Western Asiatic foreigners in the mural carry bows very similar to those from Maykop–Novosvobodnaya. A comparable double-convex bow was excavated at Sedment in Egypt (Fig. 2f), dating to the First Intermediate Period (Cook, 2018). Like the el-Makkukh bow, the Sedment bow was broken in antiquity and made from a single piece of wood. In fact, all known double-convex bows recovered from ancient Egypt, including this one, were self bows (Cook, 2018; McLeod, 1982; Western & McLeod, 1995).

The connection between Egypt and the North Caucasus may seem tenuous, but archaeological and genetic evidence highlights extensive flow of genes and culture across the Near East during the Eneolithic and Bronze Age (Pitskhelauri, 2012; Kohl & Trifonov, 2014; Lyonnet, 2014; Frangipane, 2015; Lazaridis *et al.*, 2016; Skourtanioti *et al.*, 2020; Hansen, 2021; Ghalichi *et al.*, 2024). These processes influenced iconographic styles across regions, including bow representation (Hansen, 2018, 2021; Rezepkin, 2000; Schunke, 2013). The horizontal display of bows, with the string or inner side always facing up, is consistently depicted in ancient Egyptian art, as well as in Göhlitsch and Maykop–Novosvobodnaya stone slabs. This stylistic

convention further supports the interpretation of these bows as double-convex, not double-concave, despite their misleading angular/recurved appearances.

Finally, Grave no. 3 of Kurgan no. 33, known as *Hostra Mohila*, located at the Alkaliya burial ground in the northwest Pontic steppes of Ukraine, yielded a bow fragment (Fig. 2g) that corresponds to the design depicted on the stone slab from Maykop–Novosvobodnaya in the North Caucasus. This grave, a cist burial with walls coated in red ochre, contained a body in a contracted position with knees raised (Ivanova, 2013). Assigned to the Budzhak culture—a western offshoot of the late Yamnaya—the burial dates to ca. 2500 BCE (Ivanova, 2013). Although about one-third of the bow was missing, the preserved section measured roughly 1 m in length and was unequivocally made of wood (Klochko, 2001). Based on its curvature, Klochko (2001) speculated that the bow might be composite. However, considering the absence of structural details characteristic of composite construction and corroborating the evidence from other finds, *e.g.*, the Sedment bow, it is more plausible that the *Hostra Mohila* bow was a double-convex self bow. This design aligns typologically with the bows illustrated at the Maykop–Novosvobodnaya stone slab and in the tomb of Khnumhotep II. The material culture of Yamnaya—and the preceding Mykhailivka culture—was heavily influenced by the Maykop tradition (Malory & Adams, 1997; Anthony, 2023), providing further evidence for the transmission of the double-convex bow into the steppes from a region south of the Caucasus.

By approximately 3300 BCE, Yamnaya began a widespread expansion from the Dnieper–Don region in Ukraine, extending eastward into Asia and westward into Europe, spreading their material culture—among which was the double-convex bow (Allentoft *et al.*, 2015; Haak *et al.*, 2015; Lazaridis *et al.*, 2025). For example, multiple anthropomorphic steles from the Early Bronze Age Chemurchek culture in Mongolia feature a bow that is largely similar to *Hostra Mohila* and Maykop–Novosvobodnaya bows (Kovalev, 2012). Some steles, such as the one from the Yagshiin Khodoo 3, portray bows with slight recurvatures at the tips (Fig. 2h), reminiscent of the string-hanging hooks of the el–Makkukh bow (Kovalev, 2012). The Chemurchek population descended from a genetic admixture of the Afanasievo culture—an eastern offshoot of Yamnaya—and local hunter-gatherers (Allentoft *et al.*, 2015; Jeong *et al.*, 2020; Zhang *et al.*, 2021), suggesting that the double-convex bow spread to East Asia along with migrations of Yamnaya-related groups. However, the double-convex bow seems to disappear from East Asia in the ensuing centuries, likely as a result of new migrations from the western steppes during the Middle and Late Bronze Age. These migrations, related to the Andronovo and Srubnaya cultures, introduced distinct genetic ancestries (Allentoft *et al.*, 2015; Jeong *et al.*, 2020) and possibly the full composite bow, which subsequently underwent further refinement in the region—a development discussed in the following sections.

On the other hand, in Europe, the double-convex bow persisted for much longer. While we have already seen that the late fourth millennium BCE bow from Göhlitsch is a double-convex self bow—rather than an angular composite bow—there is earlier evidence of double-convex bows. The fifth millennium BCE rock carvings at Alta, Norway, depict two distinct types of double-convex bows (Ranta *et al.*, 2020). One type, seen at the Bergbukten 1 (Supplementary Fig. 5), shows a sharp angle at the grip with tips that curve strongly toward the archer, while the other, found at

Ole Pedersen 9 (Supplementary Fig. 6), displays a more evenly distributed curvature along the entire limb (Ranta *et al.*, 2020). These bows differ from the Mesolithic and Neolithic *propeller-like* bows with flat limbs and rigid grips recovered from peat bogs across Europe (see Junkmanns, 2013). Insulander (2002), who also identified two different profiles, proposed that these bows were of wood-laminated construction, while others suggested they were composite (Kiil, 1954). However, the profiles match those of the Chogha Mish (or Natalivka) and Maykop–Novosvobodnaya (or Yagshii Khodoo) bows, as well as the el–Makkukh and Sedment/Hostrá Mohila finds, respectively. These two types of double-convex bows co-occurred in the Near East and the Pontic–Caspian steppes, and their parallel appearance in Alta suggests that the double-convex bow may have been introduced to Europe already during the Neolithic, possibly by Anatolian farmers, and subsequently spread to Norway through cultural exchanges with Scandinavian hunter-gatherers. Thus, the bows depicted in Alta rock art were probably self bows, not wood-laminated or composite.

During the Bronze Age, depictions of the double-convex bow became increasingly common across Europe. Here too, however, this type of bow has often been mistakenly identified as composite. A prominent example appears on the anthropomorphic steles from Petit–Chasseur in Switzerland, dated to the late third millennium BCE, during the Bell Beaker period (Fig. 2i; Supplementary Fig. 7). Four steles from Petit–Chasseur depict bows (nos. 1, 18, 20, and 25; Supplementary Fig. 7), which have been assumed to be simple self bows related to Mesolithic bows of Europe (Harrison & Heyd, 2007) or, based on their curved profiles, composite (Corboud, 2009; Ryan *et al.*, 2018). The idea that the Bell Beakers used composite bows is further inferred from the presence of stone wrist guards among the grave goods, which some interpret as indicative of the more powerful composite bow (Christensen, 2004; Rausing, 1967; Ryan *et al.*, 2018).

However, these arguments lack supporting evidence. The use of wrist guards is linked to draw weight and shooting technique, rather than the specific construction type. More importantly, based on the evidence presented thus far, the bow profile on the Petit–Chasseur steles is clearly double-convex, identical to those from Maykop–Novosvobodnaya (*e.g.*, stele no. 1; Supplementary Fig. 7) and ancient Egyptian iconography (Cook, 2018)—strongly indicating that these were self bows. The confusion likely arose from the placement of the string attachment on some steles (nos. 20 and 25; Supplementary Fig. 7), which is placed away from the tip. This creates the visual impression of an unstrung recurve bow, with the string appearing to rest along what would be the outer face of a reflexed limb (see Corboud, 2009). However, double-convex bows like those depicted on steles 20 and 25 often lacked string nocks. Instead, the string loop was secured where the limbs began to thicken toward the grip or held in place using transverse wrappings of cord just below the loop—features also documented in surviving ancient Egyptian bows (Clark *et al.*, 1974; Cook, 2018). Consequently, a hypothetical reconstruction of the Petit–Chasseur bows as composite (see Fig. 14 in Corboud, 2009) is not only unsubstantiated, but potentially misleading.

The double-convex profile is commonly seen in the Middle and Late Bronze Age iconography in both Minoan and Mycenaean cultures of the Aegean (*e.g.*, Blakolmer, 2007; Brecolaki *et al.*, 2008) and in the contemporary Nordic Bronze

Age culture of southern Scandinavia (Fig. 2j; Insulander, 2002; Skoglund *et al.*, 2022), the latter interpreted as composite (Rausing, 1967). During this period, there was a significant network of cultural contacts between southern Scandinavia, central Europe, the Aegean, and the Near East, including Egypt and Mesopotamia. The Nordic Bronze Age culture was strongly influenced by the Aegean palatial civilizations (*e.g.*, Vandkilde, 2014; Varberg *et al.*, 2015). This dynamic cultural exchange could be responsible for a shift in bow iconography. While the Hostra Mohila/Maykop–Novosvobodnaya bow type persisted in Europe until at least the Early Iron Age, as seen in Greece (Snodgrass, 1964), the el–Makkukh type present at Alta and Göhlitsch disappeared and was replaced by a double-convex design without a reflex in the handle (Fig. 1d). This new form already appeared on Bell Beaker steles (nos. 20 and 25; Supplementary Fig. 7) and later became common in Minoan and Mycenaean Greece (Brecoulaki *et al.*, 2008).

It is also worth noting the late third millennium BCE discovery of a burnt object found above a female skeleton in a grave at Bozejewice, Poland. Contrary to the earlier interpretation by Kosko & Klochko (1987), the object is almost certainly not a bow. Although its shape resembles an unstrung recurved bow and dendrological analysis indicated a mix of coniferous (central part) and deciduous wood (end parts) in its construction, this technology—where working and non-working sections of the wooden core are assembled from separate parts, using different wood for the limbs and tips—marked a significant step in the composite bow evolution, but did not appear until the early second millennium CE. No other examples of such technology have been found in Bronze Age contexts, making it unlikely that this innovation existed so early, especially without further evidence over the next 3000 years.

We have already established that the late fourth to early third millennium BCE Mykhailivka/Yamnaya bows from the eastern European steppes—such as those from the Natalivka stele and the Hostra Mohila burial—are not composite but double-convex self bows. Is there evidence of composite bow during the Middle and Late Bronze Age, post-Yamnaya period in the Pontic–Caspian steppes? The Catacomb culture, the regional successor to Yamnaya, did indeed yield a number of bows. Some scholars have speculated that Catacomb bows may have been wood-laminated or composite (Klochko, 2001; Shishlina, 1997), but this remains unsubstantiated. While most of these bows are poorly preserved (Bratchenko, 1989; Klochko, 2001; Shishlina, 1997), no definitive evidence for the composite construction has been found in any of the recovered specimens. For example, a relatively well-preserved bow from the Catacomb site of Kindrativka, near Mariupol, Ukraine (Supplementary Fig. 8), is a simple self bow (Kulbaka & Kachur, 1998; Fig. 1a). Interestingly, despite a poor preservation of bows from the Catacomb burial ground at Akkermen near Melitopol, Ukraine, the report indicates that these bows exhibited a slight bend at both the tips and the grip, with cross section being rounded at the tips and flattened at the grip (Vyazmitina *et al.*, 1960). This pattern is reminiscent of the el–Makkukh and other ancient Egyptian double-convex bows (Cook, 2018), suggesting the possibility that the Akkermen bows could also have been of a double-convex design. The Catacomb culture had a significant cultural impact on the Mycenaeans (Mallory and Adams, 1997), where the double-convex design is

well-documented, supporting the hypothesis that some Catacomb bows may have also featured a double-convex design.

Lastly, bone and antler objects from the Sintashta and Srubnaya cultures in the Trans-Ural and Pontic-Caspian steppes, respectively, have been claimed to reinforce the grips and tips of composite bows (see Shishlina, 1997; Bersenev *et al.*, 2011). However, these objects are almost certainly unrelated to archery. Neither contextual nor functional assessment supports their interpretation as components of bows, composite or otherwise. According to our definition, the presence of non-wood materials in the non-working sections of a bow does not qualify it as composite. The placement of these objects in graves at Sintashta sites provides no compelling evidence for the presence of a bow body to which they could have been attached or any clear association with archery. The Srubnaya objects were not grave goods but isolated finds from various settlements (Bratchenko, 1989). Functionally, the objects from Sintashta sites appear too elaborate, with excessive mass that would hinder the efficiency of a bow. For instance, the S-shaped objects thought to be attached to bow tips for hanging the string (Supplementary Fig. 9) would have caused significant oscillation after releasing an arrow. Furthermore, an internal channel orthogonal to the flat bases of these objects suggests they were fitted onto a peg, further challenging their connection to archery. The interpretation of other objects from Sintashta sites as an *arrow rest* (Supplementary Fig. 9) is anachronistic, as arrow rests are a feature exclusive to modern bows. The purported tip plates from Srubnaya sites (Supplementary Fig. 10) exhibit considerable variation in design and probable placement on a bow's tip, which is in stark contrast to the earliest indisputable tip plates found in the Early Iron Age sites in Cis-Baikal (see Okladnikov, 1940; Privalikhin, 1993, 2011; Mandryka, 2008). Unlike Srubnaya objects, these tip plates are elegant and uniform in design, and their lateral placement at the tips is obvious. Reinforcing non-working sections with bone or antler plates became a common feature of composite bows only since the late first millennium BCE. Thus, interpreting the Srubnaya objects as grip and tip plates may also be anachronistic.

In summary, while this reassessment of the existing evidence is not exhaustive, it underscores a crucial point: prior to the late third millennium BCE, there is a notable absence of evidence for the composite bow in either of the regions examined. The material culture of the time, particularly in the Pontic-Caspian steppes and the broader Eurasian context, reveals a widespread distribution of the double-convex self bow. Despite occasional misinterpretations of this bow profile as indicative of composite construction, particularly in the Near East and Europe, the available archaeological and iconographic evidence points to the continued use of self bows. This reinforces the idea that composite bow technology, as understood here, was a later development and its absence in the studied period is a key observation in tracing the evolution of the bow-and-arrow technology across these regions.

Angular Bow—The First Composite?

The earliest depictions of angular bows from western Asia, predating the New Kingdom angular bows, appeared around 2200 BCE. These are represented by

two lesser-known Mesopotamian reliefs: Darband-i Belula and Darband-i Gawr (Fig. 3a, b). Although the grips in both depictions are obscured by the hands of the figures holding the bows, the limbs form a distinct angle. The straight outlines of the limbs and the orientation of the bows in the hands confirm they are angular bows. Despite the relative straightness of the limbs, a slight recurve is visible in their terminal sections, suggesting that physical bows represented in the reliefs might have been reflexed when unstrung. The combination of reflexed limbs and an angular grip aligns with characteristics of Egyptian composite bows, implying that the bows depicted in the Darband-i Belula and Darband-i Gawr reliefs may also have been of composite construction.

An important clue for understanding the evolution and chronology of the full composite technology is the angular grip. This feature likely developed from an earlier bow design with a non-angular grip. Two key issues emerge from this: firstly, the angular grip likely served a specific functional or structural purpose; secondly, it remains uncertain whether the earlier, non-angular form already had composite construction.

There has been an ongoing debate about whether angular bows bent through the grip, as some depictions appear to suggest. Such bending would result in unpleasant vibrations upon release, known informally as *hand-shock*, which would compromise the bow's stability. However, modern reproductions of angular bows demonstrate that the grip remains rigid throughout an entire draw (Miller *et al.*, 1986). This suggests that the angular grip may have been introduced as a solution to enhance the stability of a bow lacking such grip. Iconographic evidence indicates that the bow design preceding the earliest angular bows was the double-concave bow. Examples of double-concave bows can be seen on multiple steles, primarily from the Akkadian period, including the Kalki seal or the famous stele of Naram-Sin (ca. 2250 BCE; Fig. 3c, d). When strung, these bows exhibit a more pronounced recurve in the limbs compared to the earliest angular bows, as well as a continuous arc through the central section. Notably, in depictions showing double-concave bows when drawn, *e.g.*, the Lugal-Sha seal or Rimush stele, significant bending in the grip is evident (Randall, 2016). This suggests that the angular bow might have evolved from some form of double-concave bow, with the angular grip representing the defining innovation that distinguished it from its predecessor. However, material and iconographic evidence shows considerable variability in the degree of grip bend in both angular and double-concave bows (Fig. 3), and the two profiles are sometimes conflated in the literature. For example, Rausing (1967) argued that the relief of Darband-i Belula depicts double-concave, not angular, bow. This may imply a gradual, continuous transition rather than a sharp distinction between the two designs. While angular bows are known to have been steam-bent to achieve their shape, it is likely that the same technique was used for double-concave bows. Essentially, the angular bow can be understood as a double-concave bow in which the grip bend is concentrated within a much shorter section of the bow body. Assuming both designs had similar lengths, this concentration of the grip bend would effectively extend the working section of the limbs, eventually resulting in a less reflexed appearance when strung compared to double-concave bows, as seen in iconography (Fig. 3a–d).

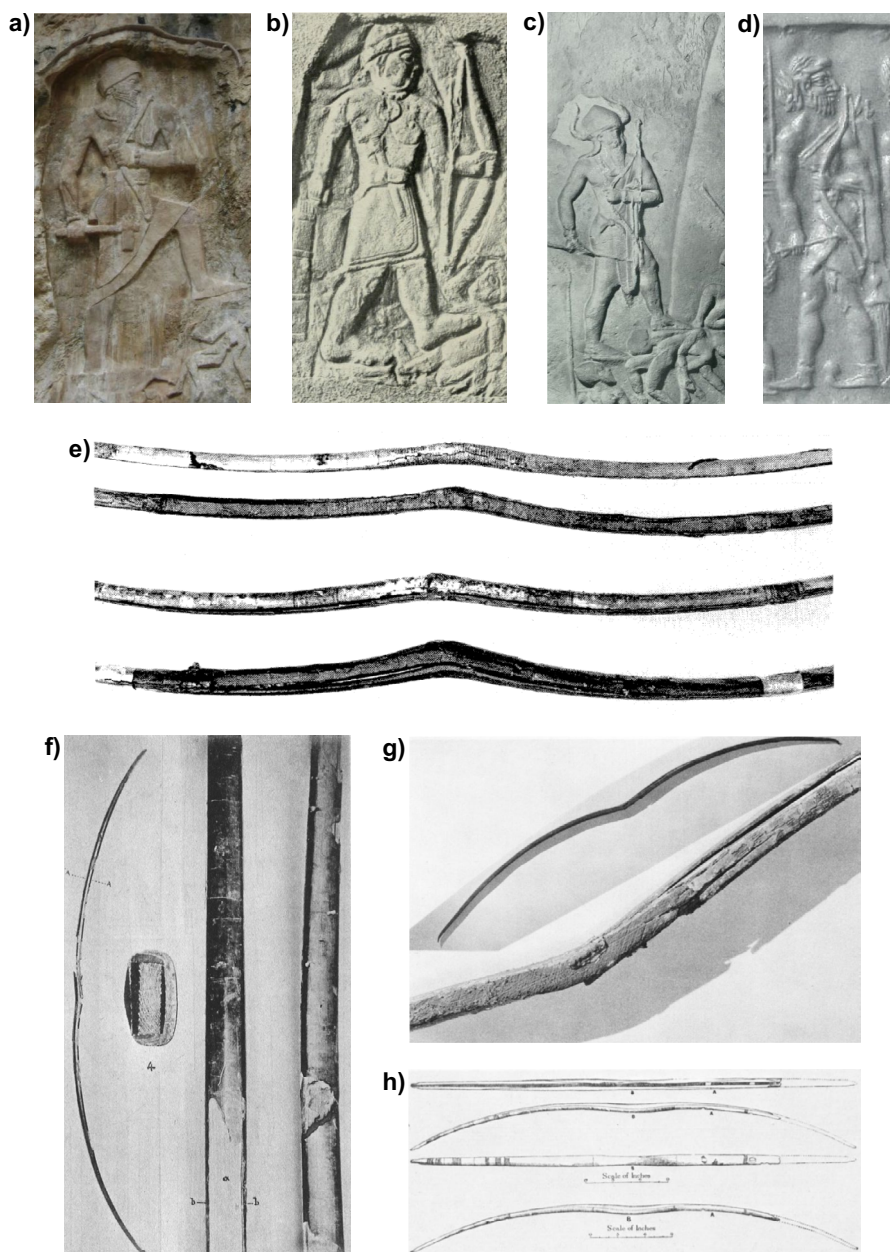


Fig. 3 Iconographic and material evidence of double-concave and angular bows of the Akkadian and New Kingdom periods from Mesopotamia and Egypt. **a** Darband-i Gawr, Iraq (from Randall, 2016). **b** Darband-i Belula, Iraq (from Weber, 1922). **c** Naram-Sin, Iraq (from Randall, 2016). **d** Kalki, Iraq (from Randall, 2016). **e** Tutankhamun's tomb, Thebes, Egypt (from McLeod, 1970). **f** Thebes, Egypt (from Balfour, 1897). **g** Saqqara, Egypt (from McLeod, 1958). **h** Thebes, Egypt (from Longman and Walrond, 1901)

Therefore, the evolution from a double-concave to an angular design seems to be a plausible development.

The second issue cannot be answered directly because there are no finds of double-concave bows. Moreover, while Egyptian angular bows all share an angular profile, their construction varies from bow to bow, even among those from the same site and period, like the bows from Tutankhamun's tomb (McLeod, 1970). Some bows adhere to the standard horn–wood–sinew construction, while others, like the bow described by Balfour (1897), feature horn on both the inner and outer surfaces (Fig. 3f). Many specimens also incorporate lateral wooden laths along the limbs (Fig. 3f, g; Supplementary Fig. 11; Balfour, 1897; McLeod, 1958, 1962). Notably, two angular bows from Tutankhamun's tomb appear to be wood-laminated and have a sinew layer but lack horn entirely (McLeod, 1970). Another example, described by Walrond and Longman (1901), features a narrow strip of horn sandwiched between two lateral wooden strips (Fig. 3h). This is the only known specimen of an angular bow where the wooden strips are composed of multiple shorter sections using scarf joints. One of the bows from the Cairo Museum demonstrates yet another variation—a wooden core flanked by horn on both the inner and outer surfaces but no sinew layer (McLeod, 1970). Many specimens also include shorter plates made of horn or wood in the grip area, which function as reinforcements. The cross-sections of angular bows at or near the grip exhibit a wide range of shapes, from rounded to flattened elliptical, and some even include a *keel* on the inner side (McLeod, 1970). Nocks are typically formed as recurved peg-like protrusions (Fig. 3f, g; McLeod, 1970). The bows of Tutankhamun feature a short vertical groove on the inner side, just below the tips, running along the stave to prevent the string from slipping sideways (McLeod, 1970).

There is no clear trend in the preserved angular bows toward a specific type of composite construction, whether over time or in terms of complexity (McLeod, 1970). For instance, the relatively simple wood-laminated construction is not confined to the earliest examples, while the most complex configuration—with horn on both the inner and outer surfaces and wooden laths along the sides—appears in both the oldest and most recent angular bows (see Balfour, 1897; McLeod, 1962). This evidence demonstrates that multiple methods for constructing angular bows coexisted for centuries in the Near East. It also suggests that the typical horn–wood–sinew composite design had not yet become fully standardized.

However, if the earliest angular bows were full composites—with the angular grip as their sole innovation—it would imply that double-concave bows from the late third millennium BCE had already been constructed using full composite technology. Alternatively, both double-concave and early angular bows may have been partial composites—such as wood–wood–sinew or horn–wood–horn, similar to some Egyptian specimens—with partial composite technology existing for a relatively short period before the development of the full composite bow. In this case, full composite technology would have emerged once angular design had already existed. In other words, several partial composite construction methods may have co-existed, with full composite technology first emerging among angular bows, a development which would have likely taken place in the early second millennium BCE. This would explain the diversity in angular bow construction methods, with

horn–wood–sinew being just one of them, reflecting evolutionary radiation following the introduction of full composite technology. As discussed later, this diversity persisted into the Iron Age, evident in the composite bows of *Scythian* groups in the Eurasian steppes, which likely evolved from angular bows. This scenario could also explain the near-absence of partial composite forms among angular bows and their widespread adoption in contrast to the double-concave design, both within the Near East and beyond in subsequent centuries. Major cultural innovations of the Bronze and Iron Ages, such as the domestic horse, the spoke-wheeled chariot, and horseback riding, rapidly spread across Eurasia within a few centuries after their emergence and have had a lasting impact (Drews, 2004). The introduction of the angular bow to Egypt during the late Second Intermediate Period aligns well with the emergence of full composite technology in the first half of the second millennium BCE.

The Spread of the Composite Bow Across Eurasia in the Late Bronze Age

Our reassessment of the iconographic and material evidence for the composite bow in the Eurasian steppes, as well as other regions, during the Early and Middle Bronze Age revealed that, in most instances, it was a double-convex self bow. The absence of evidence for the composite bow in this period can likely be attributed to the fact that this technology had not yet been developed. However, the situation in the steppes changed during the Late Bronze Age.

Located along the ancient Silk Road in northwest China, Xinjiang held significant historical importance as a conduit for cultural exchange between Eastern and Western Eurasia. The region's extreme aridity has contributed to the exceptional preservation of organic materials. Among the most notable sites is the Yanghai cemetery in northeastern Xinjiang, which has yielded several remarkable finds: the oldest known trousers, the earliest knotted carpet, and what may be the world's oldest horse saddle (Beck *et al.*, 2014; He, 2019; Wertmann *et al.*, 2023). Importantly, over 100 composite bows have been recovered from Yanghai, making it the largest assemblage of such bows in China, and possibly in the world (Karpowicz & Selby, 2010; Zhongyuan & Degang, 2024). Despite the importance of these discoveries for the study of the composite bow, and the bow-and-arrow technology in general, existing publications in both Chinese and English languages offer only a superficial overview or cover just a small portion of the entire collection (*e.g.*, Dwyer, 2003; Karpowicz & Selby, 2010; Li & Zhang, 2019; Zhongyuan & Degang, 2024).

Yanghai, along with the nearby Jiayi and Shengjiindian cemeteries, which have also yielded composite bows, was part of the Subeshi culture (Beck *et al.*, 2014; Nong *et al.*, 2023; Wertmann *et al.*, 2023). Given the long duration of the Subeshi culture in the region, from ca. 1300 BCE to 200 CE, the bows from Xinjiang display considerable variation in design and construction. Although only five Yanghai composite bow specimens have been radiocarbon-dated (Zhongyuan & Degang, 2024), the dates cover almost an entire 1500-year duration of the Subeshi culture, allowing for the identification of several evolutionary trends. The earliest known composite bow from Yanghai (IM157:11)—recovered from the same grave as the world's oldest known trousers—is represented by a terminal limb

section from around 1200 BCE. Measuring approximately 20 cm in length, the specimen still retains a piece of leather bowstring (Zhongyuan & Degang, 2024). The bow fragment displays a pronounced recurve but is poorly preserved overall, limiting further analysis of its design and construction. While composite bows from the early Yanghai period are less abundant than those from later periods, the better-preserved examples often exhibit an angular profile. Angular bows have also been found at the nearby Jiayi cemetery (Supplementary Fig. 12). Unlike the Egyptian angular bows, those from Xinjiang show notable asymmetry: the lower limb is shorter and more recurved, while the upper limb is longer and less recurved (Figs. 1f and 4a, b). Both the only radiocarbon-dated angular specimen from Yanghai (IIM13:5; Fig. 4a) and finds from the Jiayi cemetery date to ca. 800 BCE (Nong *et al.*, 2023; Zhongyuan & Degang, 2024). Interestingly, many Yanghai bows feature an extra bend in their upper limbs. While some of these bows have two identical angular bends and, overall, are symmetrical (Fig. 4c), others show a more extended and subtle bend that tends to take on a convex shape (Figs. 1g and 4d). These bows, however, remain asymmetrical. The upper limbs exhibit a similar degree of recurve to the lower limbs. Occasionally, several specimens feature a pronounced recurve at their terminal sections, a characteristic commonly found in later Yanghai bows. The construction methods of Yanghai bows closely resemble those of Egyptian angular bows, typically featuring a wooden core with horn on both the inner and outer surfaces, wrapped in sinew (Fig. 4a, b). Other examples follow the standard horn–wood–sinew construction or have horn sandwiched between two lateral wooden strips (Fig. 4c, d), akin to the angular bow described by Walrond & Longman (1901). The cross-section of the limbs is usually round or oval, though some specimens have an almost triangular cross-section, forming a *keel* on the inner side. Like Egyptian angular bows, the nocks of Yanghai bows are formed as peg-like protrusions and are sometimes recurved (Fig. 4b). A unique nock found only in Yanghai bows consists of a pair of lateral grooves. All Yanghai bows additionally lack birch bark covering.

Bows with similar profiles to those from Yanghai may be depicted on numerous anthropomorphic steles, known as *deer stones*, found across Mongolia and surrounding regions in Kazakhstan, Russia, and China, including Xinjiang (Fitzhugh, 2017). These deer stones are typically accompanied by *khirigsuur* burial mounds. Together, deer stones and *khirigsuurs* form a single mortuary and ceremonial tradition of the Late Bronze Age steppes of eastern Eurasia, referred to as the Deer Stone–Khirigsuur Complex (DSKC) (Fitzhugh, 2009, 2017). The DSKC horizon coincides with the early phase of the Subeshi culture (Fitzhugh, 2017). The bows carved on deer stones display considerable variation in size and curvature, yet their overall shape remains relatively consistent: a short, recurved lower limb, a sharp angular bend at the grip, and a long, bulging upper limb (Fig. 4e). Several of these bows show two angular bends, similar to some specimens from Yanghai (see Volkov, 1981; Zhongyuan & Degang, 2024). Notably, arrows are almost always depicted directly above the lower angular bend (Fig. 4e; see also Volkov, 1981), which suggests that DSKC bows could be a form of asymmetrical angular bow, or derived from such. Therefore, DSKC bows might have been composite in construction, likely related to the Yanghai and Jiayi bows of the Subeshi culture.

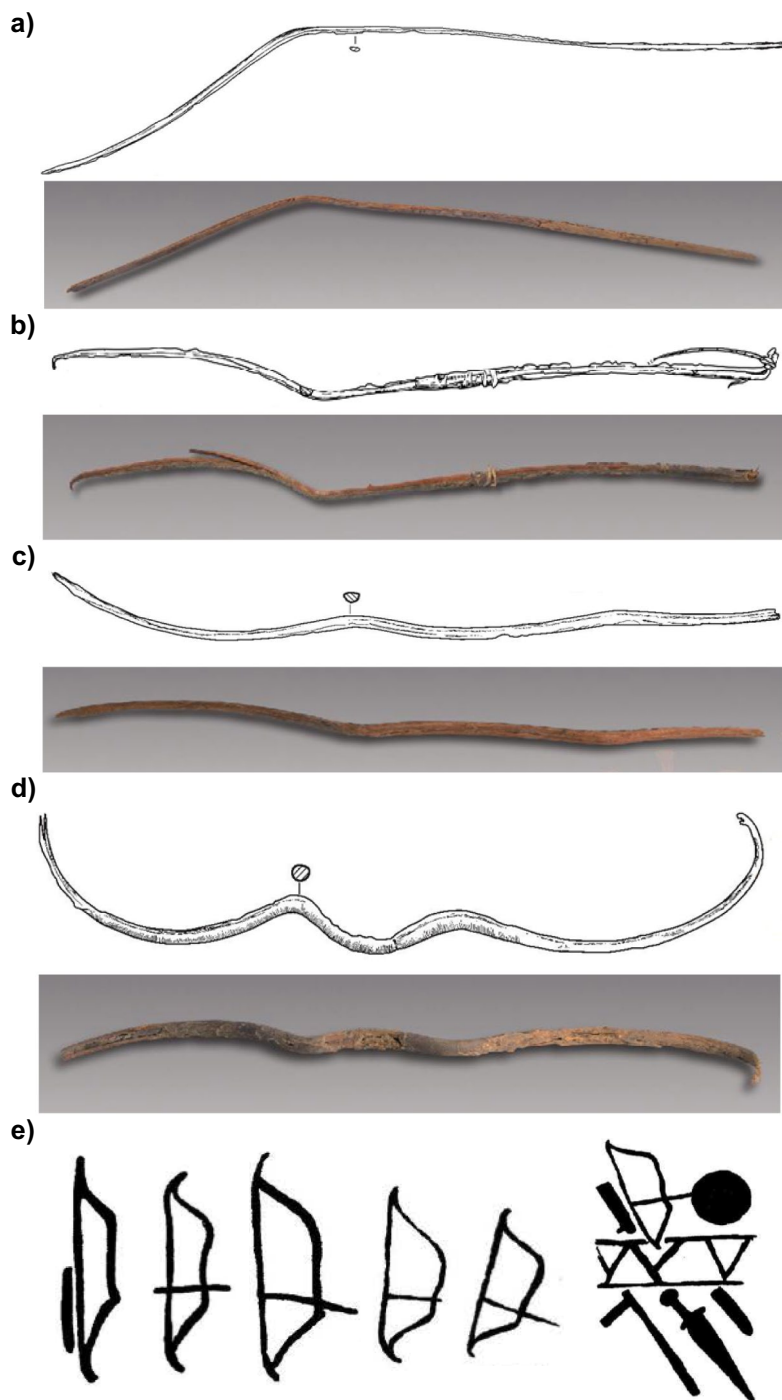


Fig. 4 Iconographic and material evidence of Yanghai and DSKC bows. **a–d** Yanghai, China (top to bottom: IIM13:5, IM164:5, IM173:5, IIM76:3) (from Li & Zhang, 2019). **e** DSKC, Mongolia (from Volkov, 1981)

Identifying early Yanghai/DSKC bows as angular has important consequences for the advancement of our understanding of the composite bow origin and spread. Given the many similarities in profile and construction between Yanghai/DSKC and Egyptian angular bows, it strongly suggests that they share a common origin. Younger ages of the dated composite bows from Yanghai compared to Egyptian ones suggest a west–east transmission, while the presence of multiple unique traits in Yanghai/DSKC bows—indicating evolutionary change—suggests that this transmission has likely occurred prior to the late second millennium BCE (Zhongyuan & Degang, 2024).

A similar bow profile to Yanghai/DSKC bows is also depicted on oracle bones from Anyang in China, dating to the late Shang dynasty (Rausing, 1967). Archaeological evidence indicates that the late Shang dynasty was significantly influenced by the DSKC, Karasuk, and other steppe cultures to the north, adopting domestic horse and chariot, as well as bronze weaponry (Chernykh, 2008; Rawson, 2015; Rawson *et al.*, 2020; Taylor *et al.*, 2017). Therefore, it is reasonable to assume that the composite bow was introduced to China from the steppes as part of this military complex, not the other way around, as suggested previously (see Anthony & Brown, 2011).

As noted, the early second millennium BCE saw new waves of migration into East Asia by populations genetically linked to the Andronovo and Srubnaya cultures, reaching Xinjiang and the Altai–Sayan regions (Jia *et al.*, 2017; Kumar *et al.*, 2022; Wang *et al.*, 2021). In the Altai–Sayan, Andronovo groups intermixed with local populations, giving rise to the Karasuk culture, which exerted considerable cultural influence on the DSKC (Allentoft *et al.*, 2015; Fitzhugh, 2009, 2017; Keyser *et al.*, 2009). Moreover, horses interred at Karasuk, DSKC, and Xinjiang sites—including Yanghai—belonged to the DOM2 lineage and appeared alongside the chariot in these regions by the mid-second millennium BCE (Honeychurch *et al.*, 2025; Taylor *et al.*, 2020), suggesting that the composite bow introduction to East Asia might have occurred earlier than the currently oldest dated specimen from Yanghai.

Thus, following the development of full composite bow technology in the Near East, or alternatively in the Volga–Ural steppes—with the Caucasus or the Iranian Plateau serving as transmission corridors—the Andronovo and Srubnaya cultures may have acted as key vectors for its diffusion eastwards. In either scenario, the composite bow likely appeared in the steppes during the first half of the second millennium BCE, roughly contemporaneous with its appearance in ancient Egypt. This rapid spread suggests that, once invented, composite bow technology spread across Eurasia within a few centuries, mirroring the transmission patterns of other major innovations of the Bronze and Iron Ages, such as the domestic horse, the spoke-wheeled chariot, and horseback riding.

Further Development of the Composite Bow in the Iron Age

During the Early Iron Age, new groups of nomads—represented by the Tagar, Aldy–Bel, Saka, Pazyryk, or Scythian cultures—emerged across the Eurasian steppes. These horse-riding, highly mobile pastoralists flourished between

approximately 900 and 300 BCE. They shared a common material culture, characterized by distinctive weaponry, horse gear, and *animal-style* art (Alekseev *et al.*, 2001; van Geel *et al.*, 2004; Bokovenko, 2006; Cunliffe, 2019).

Composite bows from this *Scythian* period continued the Yanghai/DSKC tradition. The bows exhibited a clear trend from the earlier simple angular designs to the more complex forms featuring two bends in their central section, as discussed (Fig. 1g, h; Fig. 4a–d). Several of these bows have been discovered in Mongolia, Russia, and Ukraine. The earliest known specimen was found in Grave no. 5 at Zimogorye, Ukraine (Fig. 5a; Dubovskaya, 1985). This bow was asymmetrical, with slightly recurved limbs and was constructed from two parallel wooden strips wrapped in birch bark. It dates to ca. 800 BCE and has been associated with the Chernogorovka–Novocherkassk culture (Dubovskaya, 1985).

A similar bow was uncovered in Grave no. 5 of the royal kurgan Arzhan 2 in Tuva. Although poorly preserved, it appears highly asymmetrical, with two bends in the central section and recurved limbs (Chugunov *et al.*, 2010). The bow was of wood-laminated construction, though it remains unclear whether the wooden parts were arranged side by side or stacked. It was reinforced with two extra lateral wooden plates in the section between the bends, and the bow was wrapped in birch bark. Given the substantial thickness of the limbs and the golden decorations on the bow, it has been suggested to represent a ceremonial, non-functional piece. The Arzhan 2 kurgan has been dated to around 700 BCE and belongs to the Aldy–Bel culture (Chugunov *et al.*, 2010; Sadykov *et al.*, 2020).

Archaeologists have noted material culture similarities, for example in the design of bone arrowheads, between the Chernogorovka–Novocherkassk and Arzhan complexes, suggesting that the former represents an early westward expansion of Iron Age nomads from the Altai–Sayan region (Dubovskaya, 1985; Klochko *et al.*, 1997; Olbrycht, 2000; Alekseev *et al.*, 2001; Cunliffe, 2019), which could account for similarities in the construction of these bows.

Another example was recovered from Grave no. 5, Kurgan no. 4 at the Filippovka 1 burial ground in the southern Ural region of Russia, dated to the early Sarmatian period ca. 500 BCE (Supplementary Fig. 13; Yablonsky, 2013). The bow was asymmetrical, featuring two bends in the central section and slightly recurved limbs, though the tips appear to lack a pronounced recurve. However, due to the absence of construction details in the published report, a more thorough assessment or comparison with other specimens is not currently possible.

Several late *Scythian* period bows from the Pontic steppes of Ukraine have been documented by Daragan (2020). One nearly complete bow was found in Grave no. 4 of Kurgan no. 8 near Vodoslavka village, Azov (Fig. 5b). This bow was asymmetrical with two bends in the central section and slightly recurved limbs, constructed from two stacked wooden laths and wrapped with sinew. Some parts of the limbs had a triangular cross section (Daragan, 2020). An incomplete bow from Grave no. 4 near Vladimirovka village was also asymmetrical, with two bends in the central section and recurved tips (Supplementary Fig. 14). Its body was made from a single piece of wood and wrapped with sinew. Both the Vodoslavka and Vladimirovka bows featured grooves at the tips for string attachment and were found in graves of adolescents (Daragan, 2020). Additionally, two bows from Brilyovka and

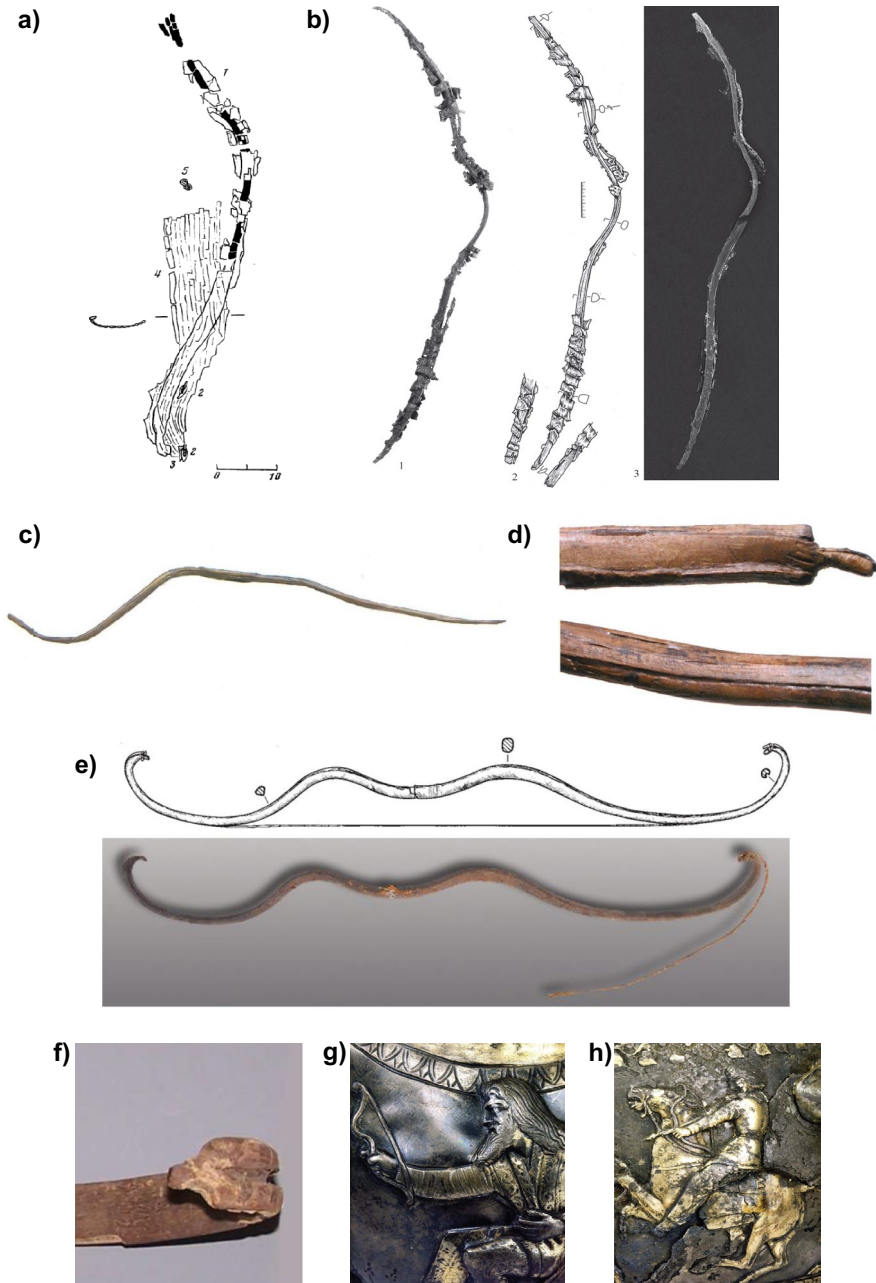


Fig. 5 Iconographic and material evidence of the *Scythian* period bows. **a** Zimogorye, Ukraine (from Dubovskaya, 1985). **b** Vodoslavka, Ukraine (from Daragan, 2020). **c** Olon-Kurin-Gol 10, Mongolia (from Molodin *et al.*, 2012). **d** Olon-Kurin-Gol 10, Mongolia—details (from Molodin *et al.*, 2012). **e** Yanghai (IIM18:6), China (from Li & Zhang, 2019). **f** Yanghai, China (from Karpowicz & Selby, 2010). **g** Chastye, Ukraine (from Daragan, 2020). **h** Solokha, Ukraine (from Daragan, 2020)

Ryzhanovsky kurgans were poorly preserved but were also asymmetrical with two bends in their central section and recurved limbs, while presumably made of single pieces of wood. The Brilyovka bow had recurved tips. All four bows date to ca. 400 BCE (Daragan, 2020).

Lastly, a completely preserved bow was found in Grave no. 1 at the Olon–Kurin–Gol 10 burial ground in the Mongolian Altai (Fig. 5c; Molodin *et al.*, 2012). Although its original shape is not fully preserved, it was likely asymmetrical with recurved limbs, though no curvature in the central section can be observed. The bow was of wood-laminated construction, with the limbs constructed from two stacked wooden laths, and two additional laths attached laterally (Fig. 5d). The limbs were connected to the grip using scarf joints. Four wooden plates reinforced the grip—two on the outer side and two laterally. The tips featured peg-like protrusions with vertical grooves on the inner side beneath them. The entire bow was wrapped in birch bark. The site is associated with the Pazyryk culture and dates to ca. 300 BCE (Molodin *et al.*, 2012).

Bows featuring two bends in the central section appear to have been widespread across Eurasia during the Early Iron Age. This design is frequently depicted on Greek vases portraying so-called *Scythian* archers (Ivantchik, 2006). These illustrations include both symmetrical and asymmetrical bows characterized by two distinct angular bends in the central portion, often accompanied by pronounced recurves at the tips. The vase imagery from around 600 BCE reflects a transitional phase in this bow design. By around 400 BCE, these transitional forms were largely supplanted by a more standardized type. One representative example is the bow IIM18:6 from Yanghai (Fig. 5e). While it retains an asymmetrical shape, both bends in the central section are convex, rather than angular, and the limb tips exhibit strong recurves. The bow terminates in peg-like nocks with vertical grooves on the inner side, and the limbs have a typically triangular cross section.

Like bow IIM18:6, most Yanghai specimens from this period were constructed using a wooden core, horn on both the inner and outer surfaces, an outer layer of sinew, with the entire bow wrapped in sinew. Other examples featured a construction in which the horn was sandwiched between two wooden strips (Karpowicz & Selby, 2010). The limbs were typically composed of shorter segments joined using scarf joints, including at the grip section, which was often reinforced with additional lateral wooden plates. In certain specimens, horn plates were also applied to specific areas along the inner side of the limbs. The regions where the two bends occurred were usually narrowed and stacked, distinguishing them structurally from the rest of the limb.

The precise origins of this *classical Scythian* design of ca. 400 BCE (Fig. 1h) remain unclear. However, based on their morphological features, it is evident that these bows ultimately evolved from angular composite bows. Several shared traits support this argument—for instance, the peg-like nocks with vertical grooves (Fig. 5f), the triangular or keeled cross section of the limbs (Fig. 5e), and the use of horn on both the inner and outer surfaces. The composite construction of late Yanghai bows—specifically, a central horn core sandwiched between scarfed wooden strips, as described by Karpowicz & Selby (2010)—closely resembles the angular bow type described by Walrond & Longman (1901). Similarly, the wood-laminated

design with lateral laths observed in the Olon–Kurin–Gol bow parallels that of bows recovered from Tutankhamun’s tomb.

Further evidence of this technological and morphological continuity lies in where these bows were held—typically at the lower angular bend—a feature consistent with DSKC bows (Fig. 3e), Greek vase paintings, and illustrations on vessels from *Scythian* kurgans (Fig. 5g, h; see Ivantchik, 2006; Cunliffe, 2019; Daragan, 2020). Nonetheless, certain distinctive traits—particularly the asymmetrical design and the introduction of an additional bend in the upper limb, first angular and later convex—represent innovations that developed after the arrival of composite bow technology in Xinjiang and Altai–Sayan regions. Successive waves and mutual exchange of angular bows across regions over several centuries are possible.

An unresolved question is the co-existence of multiple construction methods common to Egyptian angular bows, Yanghai bows, and those from the *Scythian* period. This does not appear to correlate with population structure, as revealed by ancient DNA, nor does it follow clear chronological or geographical trends. However, around 200 BCE, a distinct type of full composite bow appeared in Yanghai. Characterized by a *propeller-like* wooden core, flat limbs, rigid grip, and limb tips reinforced with laterally placed bone plates, this design also appears to already follow the standard horn–wood–sinew construction (Zhongyuan & Degang, 2024). This innovation marked a turning point, as it led to the complete replacement of earlier *Scythian-style* bows and became the foundational model from which all later composite bow traditions would develop. While this represented the onset of a new phase in the evolution of the composite bow, it is beyond the scope of this paper.

Discussion

This study presents a critical reassessment of current knowledge on the development of the composite bow, with a particular focus on refining its origins in both space and time. Drawing on a comprehensive analysis of iconographic data, supported by material artifacts and interpreted within a broader historiographical context, this review challenges several prevailing assumptions.

One major source of confusion in earlier scholarship has been the inconsistent definition of the composite bow. The tendency to classify any bow incorporating non-wood materials as *composite*—regardless of whether these materials are present in working or non-working sections—has led to misleading interpretations. This study emphasizes the necessity of distinguishing between partial and full composite technologies in studies about the origin of the composite bow. It argues that bows using partial composite construction in more recent periods are likely derivatives of the full composite bow, rather than evidence of independent evolution.

This review also demonstrates that many bows previously interpreted as early composite examples were, in fact, double-convex self bows. This insight undermines long-held claims that the composite bow originated as early as the fourth millennium BCE, for which credible evidence remains lacking. Instead, it is proposed that (1) the full horn–wood–sinew composite bow was a Late Bronze Age innovation—most likely emerging in the first half of the second millennium BCE and that (2)

this technology originated only once—likely in the Near East, or alternatively in the Volga–Ural steppes—and then spread rapidly across Eurasia (Fig. 6). The presence of composite bows in both Egypt and Xinjiang around the mid-second millennium BCE supports a model of rapid diffusion from a single point of origin. The angular design of bows in these regions further reinforces this hypothesis. The archaeological and ancient DNA evidence suggests that the spread of the composite bow occurred through a combination of cultural diffusion and population movement.

While other major cultural innovations of the Bronze and Iron Ages—such as the domestic horse, the spoke-wheeled chariot, and horseback riding—do not appear to have directly influenced the origins of the composite bow, or their roles remain uncertain, they were crucial to its diffusion across Eurasia. The composite bow initially spread in conjunction with chariotry and later with mounted warfare. DOM2 horses played a key role in facilitating these expansions. Studies tracing the dispersal of DOM2 horses and the timing of their appearance across Eurasia (e.g., Librado *et al.*, 2024; Honeychurch *et al.*, 2025) may offer valuable insights into the spread of the composite bow as well.

For instance, the arrival of DOM2 horses in the Xinjiang and Altai–Sayan regions during the mid-second millennium BCE aligns with the proposed timeline for the introduction of the composite bow into East Asia, as discussed here (Fig. 6). The identification of DSKC horses as DOM2 may give some support to the interpretation of DSKC bows as angular composite. Moreover, the introduction of DOM2 horses—alongside other military innovations—into China around 1200 BCE (Honeychurch *et al.*, 2025; Taylor *et al.*, 2020) further reinforces the argument that

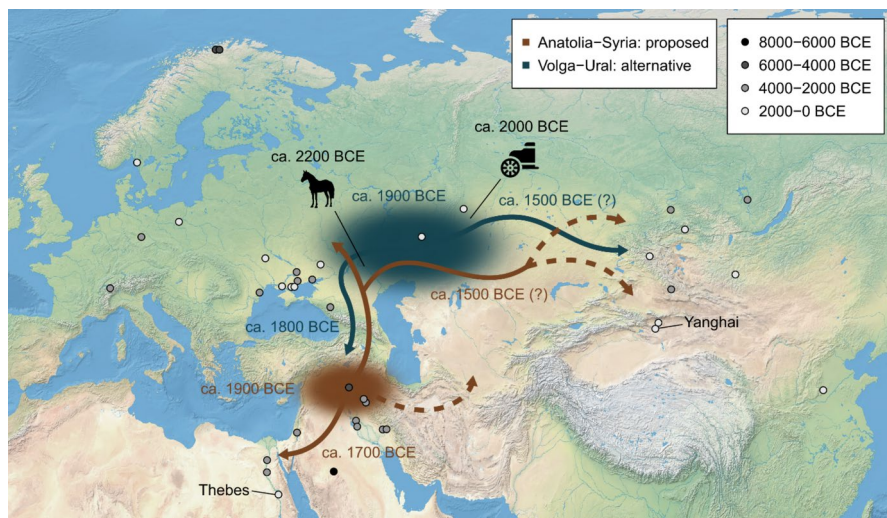


Fig. 6 Composite bow origin and spread. The map highlights proposed (Anatolia–Syria; brown shading) and alternative (Volga–Ural; cyan shading) regions of origin. Solid arrows indicate primary routes of composite bow diffusion, while dashed arrows represent alternative pathways. Points show key archaeological sites discussed in the text (see Supplementary Table 1 for the list of sites). The map also denotes the approximate regions associated with the origins of DOM2 horses (Volga–Don) and spoke-wheeled chariot (Trans–Ural), respectively. The base map is from the publicly available Natural Earth data set

composite bow technology was introduced to China from the steppes, rather than the other way around. Ongoing genetic analyses are expected to clarify whether horses were introduced to East Asia prior to the mid-second millennium BCE, and whether this occurred via southern Siberia or through the Inner Asian Mountain Corridor (see Honeychurch *et al.*, 2025). These findings may further refine our understanding of the spread of the composite bow (Fig. 6).

Much of the evidence reviewed here is associated—archaeologically or genetically—with Indo-European-speaking groups, such as the Yamnaya, Catacomb, Sintashta, or Bell Beaker (Mallory & Adams, 1997; Anthony, 2007; Allentoft *et al.*, 2015; Haak *et al.*, 2015; Jeong *et al.*, 2020; Gneecchi-Ruscone *et al.*, 2021; Kumar *et al.*, 2022; Lazaridis *et al.*, 2025). While it has often been assumed that early Indo-Europeans used composite bows (Anthony, 2007; Bratchenko, 1989; Corboud, 2009; Gimbutas, 1991; Klochko, 2001; Ryan *et al.*, 2018; Shishlina, 1997), closer examination of the existing evidence fails to support this view. In the reviewed cases, the supposed composite bows were either insufficiently evidenced and/or turned out to be double-convex self bows. In contrast, the later Andronovo and Srubnaya cultures—widely regarded as early Indo-Iranian speakers, the largest branch of the Indo-European language family (Guarino-Vignon *et al.*, 2022)—may have played a central role in the eastward transmission of composite technology during the Late Bronze Age. In eastern Eurasia, descendants of these Indo-Iranian groups, associated with so-called *Scythian* archaeological cultures, were instrumental in the further development of composite bow design, culminating in the highly distinctive *Scythian-style* bow.

This study has several practical implications for future research. Its reassessment of the time and place of the composite bow origin provides a revised set of data points for empirical studies. For instance, Turchin *et al.* (2021, 2022) studied the evolution of military technologies, including self bow and composite bow. However, they operate under the misconceptions about the antiquity of the composite bow challenged in this study—namely, that it existed as early as the late fourth millennium BCE. This critique is not intended to undermine the overall value of their work, but rather to highlight the importance of critically evaluating individual data points when addressing long-standing questions in cultural evolution.

Likewise, it is not uncommon for archaeologists and historians working with bow-and-arrow materials to misinterpret their findings due to a limited understanding of the technology itself. This underscores the need for interdisciplinary collaboration and encourages researchers to consult with specialists in bow-and-arrow studies or expert bowyers when interpreting such materials.

Despite these advances, this study's conclusions must be seen as provisional, constrained by gaps and imbalances in the available data. While certain sites—such as Thebes and Yanghai (Fig. 6)—have yielded rich assemblages of composite bows, other potentially significant regions, especially the steppes of Eastern Europe and Central Asia, have yet to produce definitive evidence of such technology for the Early to Late Bronze Age. The discussion concerning the origin of the angular bow is only speculative, and other scenarios are certainly possible. Additional promising avenues could include the analysis of ancient textual sources—particularly from the Near East—and linguistic reconstructions of proto-languages for terminology related

to composite bow technology (see Wilson, 2023), which may ultimately point to a greater antiquity for the full composite bow. Questions about the cultural macroevolution of the composite bow and of bow-and-arrow technology more broadly could be addressed through the application of cultural phylogenetics. This approach has proven effective in tracing the evolution of both material and non-material culture (e.g., O'Brien *et al.*, 2001; Tehrani & Collard, 2002; Rexová *et al.*, 2003; Gray *et al.*, 2009; Aguirre-Fernández *et al.*, 2021). Phylogenetic comparative methods also provide a valuable framework for examining co-evolutionary relationships (see Mace & Pagel, 1994) between the composite bow and other major innovations of the period, such as chariotry and horseback riding discussed above. Thus, future research holds considerable potential for resolving long-standing questions about the origins, development, and spread of this fascinating technology.

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Declarations

Competing interests The authors declare no competing interests.

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