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RESEARCH

Significance of fossils in Roman times: the first trilobite find in an early Empire context

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Abstract

Although the collection of fossils by humans is known from the Palaeolithic, the occurrence of trilobite remains in archaeological contexts is particularly rare worldwide, previously documented by specimens from sites in Western Europe, North America, South Africa and Australia. This article reports the discovery of an eleventh known trilobite found in an archaeological context, from a Roman settlement dating from the 1st–3rd centuries CE, excavated in north-western Spain (A Cibdá of Armea near the city of Ourense). The specimen represents the first confirmed trilobite from Roman times and is the third trilobite in the global archaeological record to have been collected and used by people over a thousand years ago. Its palaeontological and preservational characteristics enable us to pinpoint its probable origin to Middle Ordovician shale outcrops in south-central Iberia, over 430 km from the Roman excavation site where it was found. The modifications observed on the underside of the specimen, which exhibits up to seven artificial wear facets to flatten and shape the fossil, are interpreted as indicating its possible use within a pendant or bracelet, likely serving as an amulet with magical or protective properties.

Keywords Fossils in archaeology · Trilobites · Small archaeological objects · Roman times · Northwestern Spain

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Introduction

Fossils have long been known to humankind and have been used for various purposes, particularly as symbolic and ritual objects, but also as simple ornaments, jewelry, or even medicines. Their significance as objects across different societies, from prehistory to the present, has been analysed in several studies (e.g. Oakley 1965, 1985; Rudkin and Barnett 1979; Rudwick 1985; Mayor 2005, 2023; Duffin 2008; Mayer et al. 2010; McNamara 2010; Helm et al. 2019; Cortés-Sánchez et al. 2020; Forli and Guerrini 2022; Romano 2024; Meier et al. 2024). Fossil stones were also used for similar purposes, particularly amber and jet, which were believed to be protective stones with potential healing properties and protection against magical threats (Rudkin and Barnett 1979). In Greek and Roman antiquity, vertebrate fossils such as large bones and teeth (generally from proboscideans) were considered to be the remains of giants, mythic heroes, cyclopes, or dragons. Classical sources indicate that these remains were often deposited as offerings in temples and sanctuaries, thereby gaining these sites a certain prestige. This tradition is well attested in the Greek world,

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as these giants were part of the mythology, sharing the stage with the gods themselves (Mayor 2023).

In Roman times, we know from historian Suetonius (1997 [ca. 70–post 126], 72.3) of the interest of the Emperor Augustus in fossils, which he imported from Greece and excavated on the island of Capri, where he established the first palaeontological museum at his villa to display the bones of ancient 'giants' and 'monsters' (Mayor 2023). This passion was inherited by his successor Tiberius, who even sent embassies and missions, as reported by Phlegon of Tralles, to recover fossils after a series of earthquakes devastated Asia Minor and exposed numerous skeletal remains of prehistoric animals (Mayor 2023).

Classical sources also mention fossils of smaller organisms, such as molluscs, echinoderms, brachiopods or arthropods, although the evidence is limited. The Romans were familiar with these but identified them as ancient creatures, sometimes even as proof of prehistoric seas. All these fossils—rare objects from the Earth's deepest parts—were considered magical and protective elements in both their places of origin and where they were traded. Often, they ended up serving as offerings or votive deposits in religious sites, temples, or simple places of veneration. Unfortunately, only a few cases of invertebrate fossils recovered from Roman archaeological contexts are known (Mayor 2023; Forli and Guerrini 2022), limiting our understanding of this phenomenon.

Regarding fossil arthropods, the 'scorpion stones' mentioned by Greek authors from the 7th–4th centuries BCE and also cited by the 1st-century Roman historian Pliny the Elder (1855 [ca. 23–79], book 37, Chap. 11) have been considered by some modern researchers as cryptopalaeontology references to trilobites (Liñán and Gonzalo 2008). However, only the colour (copper red) and a vague generic shape (like the animal but lacking trilobation), on which these magical amulets against scorpion stings were based, are not conclusive enough to support such a claim. Therefore, the discovery presented in this work represents the first documented trilobite in the Roman world and the earliest known reference to this fossil group—and the intentional manipulation of a trilobite specimen—in all of classical antiquity.

The trilobite found in Armea

Identification of the fossil specimen

The fossil found at Armea corresponds to a segmented exoskeleton, which preserves parts of seven articulated rings and a terminal piece formed by a number of fused rings (Figs. 1a and 2). Two longitudinal furrows occurring in an ex-sagittal position give the specimen the classic three-part division of the dorsal carapace, characteristic of trilobites—a well-known group of marine arthropods typical of the Palaeozoic era (Kaesler 1997; Fortey 2000).

The morphology of the specimen corresponds to an incomplete thoracic and pygidial fragment of a Calymenine trilobite that remains articulated and undoubtedly belongs to one of the more common genera of the important subfamily Reedocalymenidae: *Neseuretus* Hicks, *Colpocoryphe* Novák in Perner or *Salterocoryphe* Hammann. This palaeobiogeographically diagnostic group was distributed across the Gondwana supercontinent and its peri-continental margin throughout the Ordovician period (Turvey 2005). In the closest current geographic terms, the three genera typically occur in southwestern Europe (Iberian Peninsula, France, Sardinia), parts of Central Europe (Bohemian Massif), North Africa (Morocco, Algeria, Tunisia) as well as Arabia and Turkey (Henry 1980; Hammann 1983; Hammann and Leone 1997; Rábano 1999a, b). Amongst these reedocalymenines, the Armea specimen should be identified as *Colpocoryphe* sp. due to the smooth pleural fields of the pygidium and its relatively wide rachis, although the incompleteness of the available fragment precludes a more precise identification.

Figure 1b.1 shows a reconstruction of the life habit typical for the genus *Colpocoryphe*, half-buried in the substrate in an arched posture here seen in left lateral view. In contrast, Fig. 1b.2 shows the resulting cadaveric position where the animal died and was buried in situ (Hammann 1983). A coloured recreation of the left side of the Armea specimen is projected on Fig. 1b.2, in order to show that it can correspond either to the posterior part of a buried carcass or, most probably, to part of a thorax + pygidium element that could be generated by the periodic moulting of the carapace of the living animal.

The fragment under study correspond to a so-called thorax + pygidium, which forms the main component produced by the moulting of prone specimens during their lives. This element is created following the detachment of the cephalic tagmata during moulting and before the general disarticulation of the sclerites forming the dorsal exoskeleton by marine currents or scavenger activity (Henningsmoen 1975; Drage 2019). In Reedocalymenine moulting, it is also very common for reverse telescoping to occur in the central thoracic segments, along with incipient rolling-up in the posterior 3–5 segments adjacent to the pygidium (Hammann 1983, 1985). This often complicates the distinction between an in situ carcass and a moult; however, in our case, we identify the specimen as a probable ecdysial thorax + pygidium. Moulting elements are far more frequent in the fossil record, and complete specimens in a prone death posture, rather than a rolled-up position, are rare and observed only in very specific circumstances (Hammann 1985).

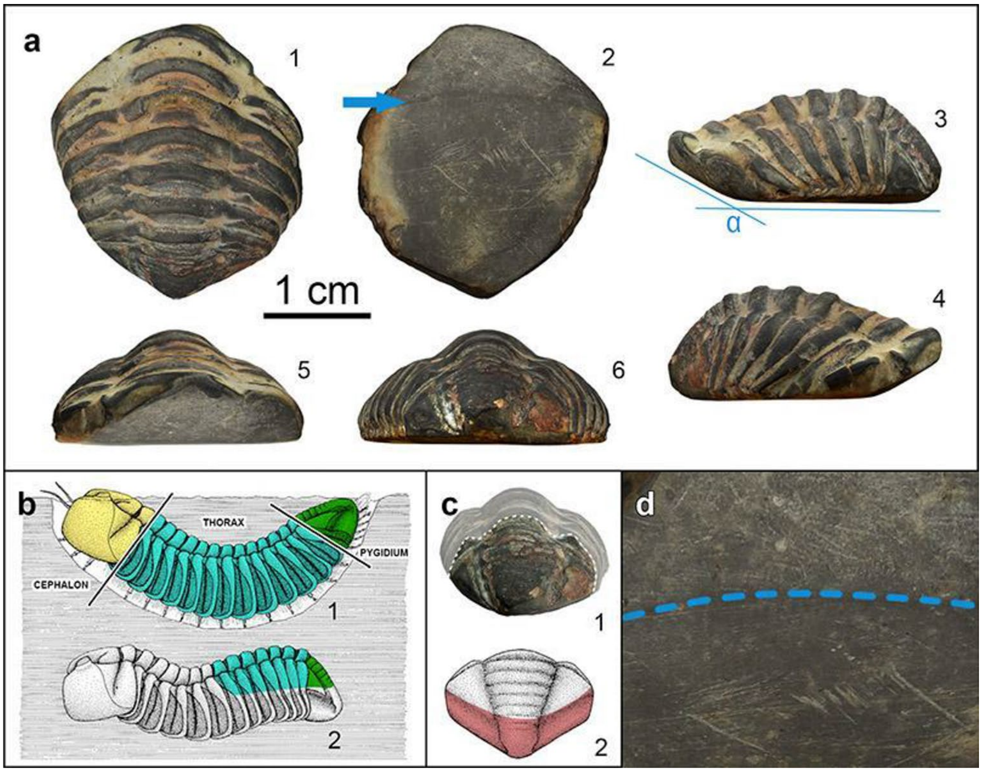

Fig. 1 Photographs and interpretation of *Colpocoryphe* sp., the Ordovician trilobite found in the Armea Roman settlement. **a**, **c**, **d**, Specimen CCA21-3965 in dorsal (a1), lower (a2), anterior (a5), posterior (a6), left-lateral (a3), and right-lateral (a4) views. α in a3 indicates the angle measured between the two main wear facets (1 and 2 in Fig. 2) of anthropic origin, whose convergence is marked by a blue arrow in a2. **b**, Reconstruction of the life habit of the genus *Colpocoryphe* (b1), half-buried in the substrate in an arched shape, and retraction of the exoskeleton after death or ecdysis (b2). The lateral view of the specimen in a3 was reproduced in b2 to clarify the positioning of the fossil. **c**, Posterior-oblique view of the specimen with enhanced pygidium (c1), to indicate the missing parts (highlighted in pink in c2) with reference to a drawing of a *Colpocoryphe* pygidium. **d**, Close view of a.2 (lower side of specimen), showing details of abrasion striae near the boundary between the angular facets (blue line). Drawings reproduced from Hammann (1983)

Taxonomic identification of different Reedocalymenine genera and species relies entirely on a combination of cephalic and pygidial details, without which fragments, strictly speaking, would not be identifiable. Although the pygidium in the fossil under study is not fully preserved, the smooth pleural fields exclude the genus *Neseuretus*, which displays well-defined pleural ribs. This feature allows us to associate the specimen with either the genus *Colpocoryphe* or *Salterocoryphe*, although species included in the latter genus have a narrow pygidial rachis. In contrast, the proportional width to the thorax in the Armea specimen is considerable. In Fig. 1c.1, the pygidial fragment is projected onto an outline of *C. grandis* Šnajdr, a species widely distributed in Sandbian (Upper Ordovician) strata across the southern Gondwanan region except for Arabia and Tunisia; it has been recorded and described in Bohemia, Ibero-Armorica, and Morocco's Anti-Atlas (Hammann 1983; Šnajdr 1956; Destombes 1966; Henry 1980; Romano 1991; Rábano 1999a, b; Gutiérrez-Marco et al. 1999; Vidal et al. 2011; Pereira 2017; Romero and Gutiérrez-Marco 2021). However, the pygidial features of the specimen also fall within the variability range of *C. rouaulti* (Henry 1980), a slightly older species from the Middle Ordovician of Ibero-Armorica (e.g. Hammann 1983; Henry 1980; Rábano 1999). Based on this, the fossil found at Armea should be identified as *Colpocoryphe* sp.

Anthropic modification of the specimen

The trilobite under study exhibits a generally rounded outline and a convex profile (tr. and sag.). As indicated above, the dorsal curvature of the exoskeleton is original and most likely corresponds to a moulting element. Specimens preserved in an initial rolled-up position (Figs. 1b.2, 2a and supplementary information), both inside and on the outer surface of siliceous nodules, typically have a significant amount of rock matrix adhered to the ventral part of the trilobite, sometimes forming a hemispherical to sub-spherical shape. However, the Armea specimen not only has a small amount of rock matrix below it, but this material has been considerably reduced through deliberate anthropic action (Fig. 2).

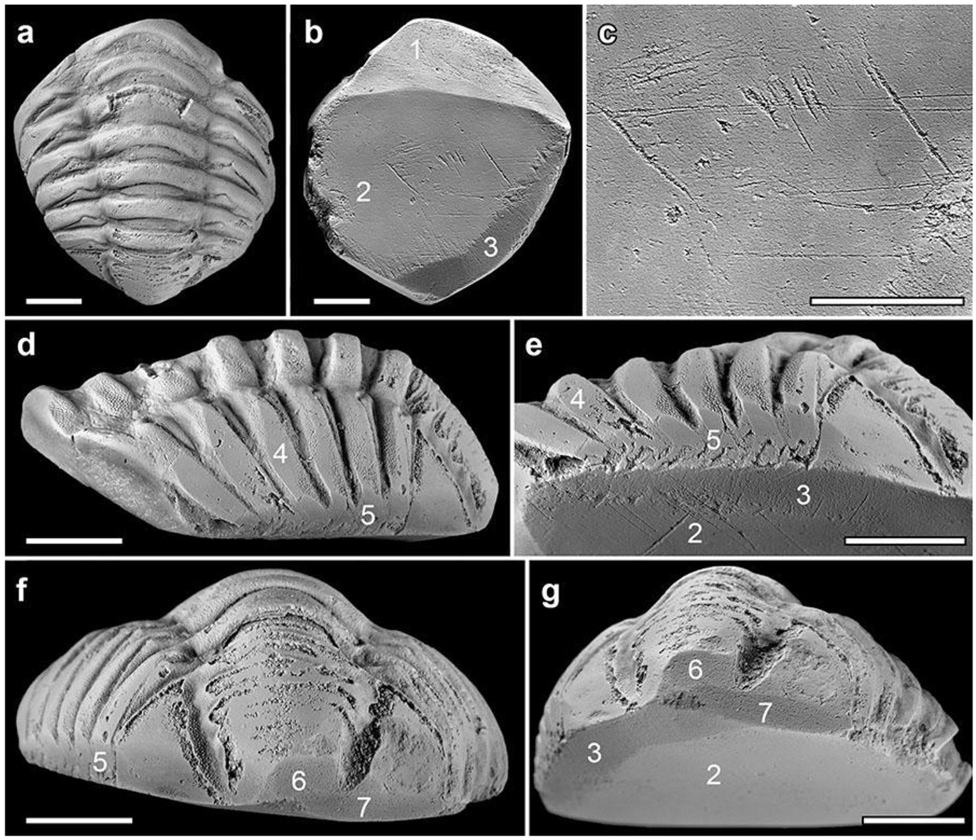

Fig. 2 High-contrast photographs of the Armea trilobite fossil, whitened with MgO vapours to highlight the recognisable marks of anthropisation on the fossil. **a**, Dorsal surface. **b**, Bottom (lower) view showing the main three wear facets 1–3. **c**, Detail of striae on the surface of facet number 2. **d**, Left-lateral view of the specimen with antero-posterior development of wear facets 4 and 5. **e**, Detail in oblique-lateral view of the lower left surface, showing the position of wear surface 3 between surfaces 2 and 5. **f**, Posterior view of the specimen showing the relative position of wear facets 5–7. **g**, Lower oblique view showing the placement of the posterior most wear facets 3, 6 and 7. Scale bars, 5 mm

The manipulation is evidenced by the presence of up to seven abrasive wear facets: the anterior facet (1 in Fig. 2b) is located approximately beneath the first two and a half thoracic segments and forms an angle of 150º (Fig. 1a.3) with another larger, flat area that extends ventrally beneath the main part of the piece (2 in Fig. 2). The junction between these two facets is a slightly curved line (arrow in Fig. 1a.2; Figs. 1d and 2b). Additionally, there are other smaller facets located on the lateral and posterior margins of the specimen (Fig. 2, nos. 4–7) aimed at correcting asymmetry and giving it a rounded appearance.

Apart from the fact that such wear surfaces are not observed in small natural nodules, which generally lack internal structure and fracture surfaces, the abrasion that produced the seven wear facets is confirmed by the presence of numerous striations, mostly very fine and oriented transversely to sub-transversely relative to the longitudinal axis of the specimen (Figs. 1d and 2c).

Locality and archaeological context: the site of Armea

The studied trilobite specimen comes from the Roman settlement known as A Cibdá of Armea, located to the north of the municipality of Allariz, about 15 km southwest of Ourense, the capital of the province of the same name in northwestern Spain (Fig. 3). The Roman ruins of A Cibdá (Fig. 4) are spread around the eponymous hill and form part of the historical-archaeological complex of Armea, which includes a wide variety of archaeological sites, spanning from the pre-Roman period to the Late Middle Ages (Fernández Fernández 2017). During the Roman period, this area was located in the north-west of the *Conventus Bracarensis*, in the ancient Roman province of *Gallaecia*. Besides A Cibdá itself, the Armea complex includes the Roman road—Camino de Santiago, which probably overlays a secondary Roman road running from *Aquae Flaviae* (Chaves) to *Lucus Augusti* (Lugo).

A Cibdá of Armea is situated on the northern slope of the hill. In the 1950s, a series of Roman courtyard houses were excavated on a terrace known as A Atalaia, flanking a stone-paved street. Systematic excavation of this area was resumed in 2011. Initially, the excavation focused on re-excavating the 1950s trenches, but from 2014, stratigraphic digging in new areas led to the full excavation of three atrium houses (Lago Cerviño et al. 2022). The archaeological record suggests that this terrace was remodeled from the beginning of the 1st century CE over a pre-Roman hillfort, which remains poorly understood. Evidence for the first Roman period includes a series of domestic and industrial (metal smelting) features found under the House of the Hexasquel (built at the end of the 1st century) (Fig. 4c) and the

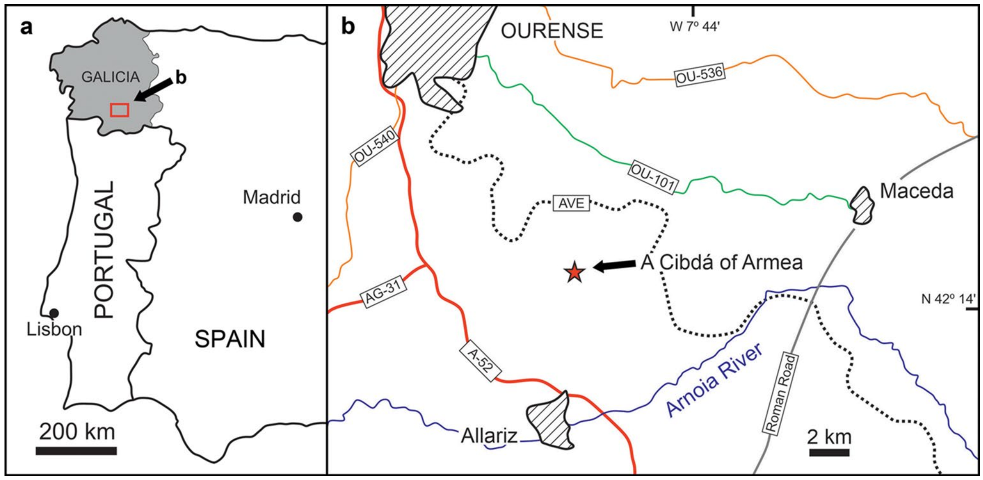

Fig. 3 Geographic setting of the Armea Roman settlement. **a**, Sketch map of the western Iberian Peninsula showing the location of the area within the Autonomous Community of Galicia – highlighted in grey –, NW Spain. **b**, Detail of the inset map in a, showing the location of the Roman city (red star). The main highways and roads are indicated in colour and by their notation numbers; the dotted line corresponds to the high-speed railway

Fig. 4 Excavations in the Armea' Roman city of 'A Cibdá' (Allariz, province of Ourense, NW Spain) at the time of the trilobite discovery. **a**, Aerial view of the site (north to the south), taking advantage of a clearing in the forest. **b**, Oblique view of the Hexasquel *domus*. **c**, A view from the south, with the Hexasquel *domus* in the back. **d**, Detail of the *atrium* of the East House

main thoroughfare, which have been dated to the final years of Augustus's reign or the beginning of Tiberius's rule. The original Roman constructions were modified in the mid-1st century CE and eventually razed during the re-urbanisation of the area surrounding the streets, where new large houses were built, likely in the late 1st century CE, during the Flavian period. The area was abandoned between the early 2nd and early 3rd centuries CE, for reasons that remain unclear, possibly related to the gradual decline of mining activities in the surrounding area or a reorganisation of the territory during the 3rd century (Fernández Fernández and Pérez Losada 2017).

During the 2021 field season, a large open room located to the north of the central street was excavated. It shares its west wall with the kitchen of the Hexasquel *domus* (Fig. 4b). This space may have served as a communal area, potentially for keeping livestock. A small structure of stones restricts direct access to the room, controlling the livestock entry (Fig. 5a). The use of this area likely contributed to the gradual accumulation of surface fill with waste, particularly organic matter, as well as discarded pottery, glass, and metal fragments. In other words, it seems also to have functioned as a dump area (Fig. 5). The trilobite specimen was found in level SU.204 of this refuse area, associated to the latest period of occupation. Above it, level SU.203 marks the destruction and abandonment of the site (Fig. 5b-c).

Among the 4,000 objects recovered from the SU.204 layer, most consist of ceramic remains, particularly common and cooking wares produced locally or regionally. These include pots (Figs. 6.j-6.l), casseroles, dishes (Figs. 6.q-6.r), mortars (Fig. 6.m), lids (Fig. 6.n), painted pots (Fig. 6.p) and jars, and even flat-bottomed amphorae (Fig. 6.o).

The chronological range of the deposit's contents appears to be quite broad, beginning around the 1st century CE. The oldest materials include a coin and fragments of South Gaulish terra sigillata, identified as Dragendorff types 15/17 and 35 (Figs. 6.c-d) dated to the mid-1st century CE (Genin 2007). The coin found in this context is an *Aes* of Augustus (Fig. 6.b) from the Calagurris mint, dated between the year 2 BCE and 14 CE (Burnett et al. 1992). Its wear suggests continued use over time, which explains its presence in this context, formed after the coin's original date.

Aside from the South Gaulish terra sigillata, the fine tableware in this context is of Hispanic production, featuring Dragendorff types 15/17, 35, 36, and 29/37 (Mayet 1983) (Fig. 6.e-6.i). Metal fragments, including bronze cauldrons and nails, were also found, along with glass objects and animal bones. Other archaeological remains, such as fine and common wares, date the deposit to around the late 2nd century, in line with other contexts associated with the occupation of the houses (Fernández Fernández et al. 2014, 2016; Valle Abad et al. 2020; Rodríguez Nóvoa et al. 2019, 2022), which seem to have been abandoned around this time. However, the deposit may have accumulated over an extended period, possibly beginning with the reorganisation of the living space and the construction of this stable area during the 1st century. For these reasons, the trilobite-bearing layer can be dated between the 1st and 2nd centuries CE.

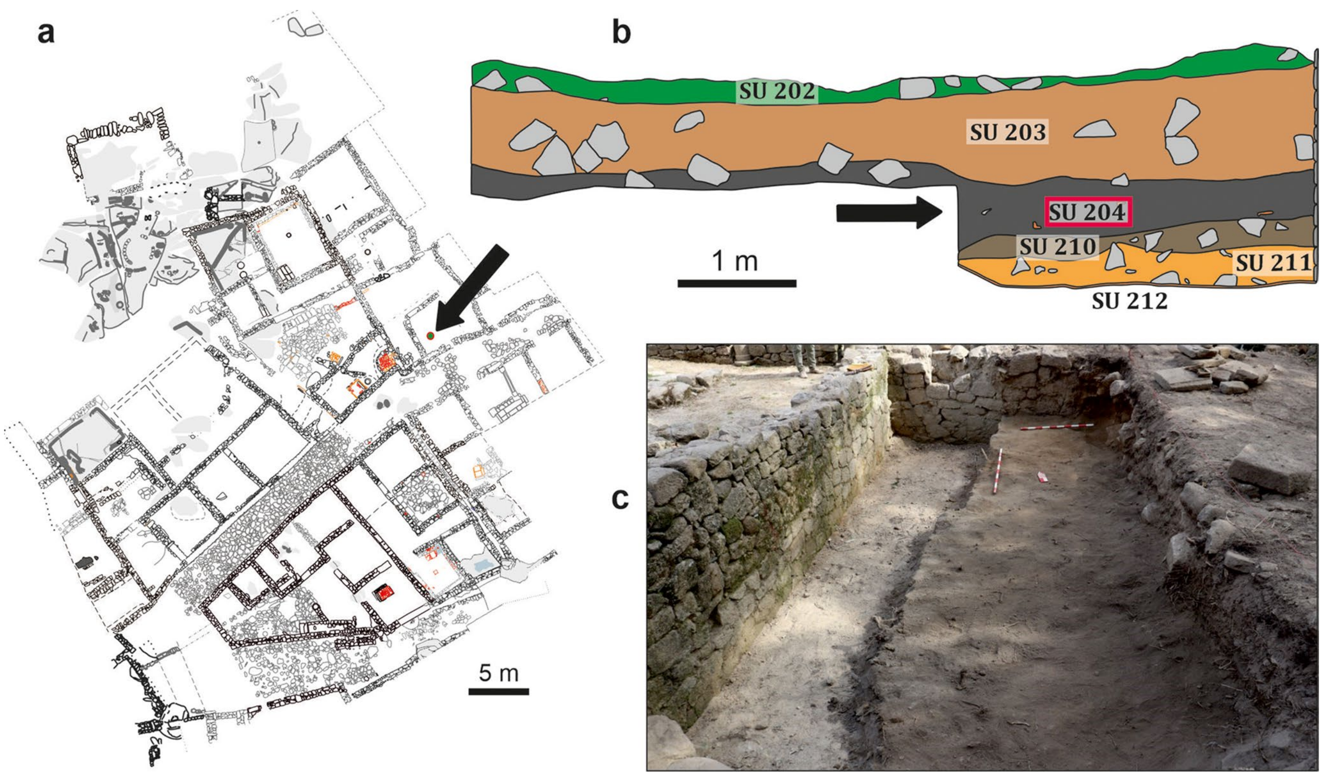

Fig. 5 Schematic location of the trilobite occurrence in the Armea Roman settlement. **a**, Planimetry of the excavated area (year 2021, north up) with the place where the fossil was found (black arrow). **b**, Stratigraphic section (north to south) showing the trilobite bearing bed (arrowed). **c**, A view of the deposit SU.204 from the south during its excavation (July 2021)

Fig. 6 Some materials dating the archaeological level SU.204 of the 2021 season of excavation in the Roman city of Armea. **a**, Trilobite. **b**, Obverse and reverse view of an *Aes* of Augustus coin (RPC 447) from *Calagurris*. **c-d**, Fine wares in South Gaulish *terra sigillata*, Dragendorff 15/17 (c) and 35 (d) types. **e-i**, fine tablewares of Hispanic production, Dragendorff 15/17 (e-f), 35 (g), 36 (h), and 29/37 (i) types. **j-r**, Common and cooking wares (j-l and p, pots; m, mortar; n, lid; o, flat-bottomed amphora; q-r, dishes)

Fossil preservation and provenance

The trilobite ecdysial thorax + pygidium from Armea is preserved as a natural cast, mineralised in iron oxide—likely hematite, Fe_2O_3. Its surface captures fine details of the external ornamentation, such as sensory granulation on the anterior thoracic segments (see 3D image in Supplementary information) and the finely preserved articular facets of the thoracic pleurae (Fig. 1a.1).

As is typical for *Colpocoryphe* specimens preserved as iron oxide casts, mineralisation occurred at a relatively advanced diagenetic stage. Here, iron minerals dispersed in the sediment precipitated within the space left by the dissolution of the original calcareous dorsal exoskeleton. This process generally occurs in a mudstone-dominated matrix and, most commonly, within siliceous nodules of very early diagenetic origin. These nodules protect fossil remains and the pore spaces below shells from compactional deformation, with trilobites casted in this way often located in the periphery of siliceous nodules. This fossilisation process aligns with the massive texture of the siliceous rock matrix beneath the fossil and the lighter-coloured clayey traces preserved in the inter-annular spaces of certain thoracic segments, suggesting contact with weathered mudstones where the nodules were embedded.

Regarding the fossil's possible origin, its taphonomic features indicate a distant source and intentional transport to the Armea settlement during Roman times. In northwestern Spain or northern Portugal, there are nearly a hundred fossil localities that yield Middle and Upper Ordovician Reedocalymenine trilobites (Gutiérrez-Marco et al. 1999; Gutiérrez-Marco and Bernárdez 2003; Sá Rábano 2010; Bernárdez et al. 2022; Romero et al. 2024). All such fossil sites are found within the Luarca, Villaflor, Moncorvo, or Sueve Formations of the Cantabrian, West Asturian-Leonese, and northern Central Iberian zones of the Iberian Massif (Gutiérrez-Marco et al. 2002). Trilobites from the Luarca and Moncorvo formations are readily identifiable due to their preservation as flattened moulds in shale and roofing slate, which show varying degree of metamorphism and tectonic deformation, also affecting fossiliferous nodules. This is also true for the Congosto fossil locality (León province), which has yielded a single record of the Upper Ordovician trilobite *Colpocoryphe grandis* in northwestern Spain from shales in the lower part of the Agüeira Formation (Romero et al. 2024). Unlike all of these occurrences, the Armea specimen is preserved in a distinct rock type as an iron oxide cast, free from any form of tectonic or diagenetic deformation.

Reedocalymenines from certain fossil sites within the Cantabrian Zone (Sueve Formation) also show no signs of tectonic deformation but are always found as internal and external moulds in dark to grey-coloured shales. The rare specimens found in nodules are never mineralised in iron or other substances, as observed in the Armea specimen.

Consequently, the mode of preservation of the trilobite under study excludes a nearby origin within the Roman province of *Gallaecia*, but the Armea specimen's distinctive taphonomic characteristics allow us to determine its probable origin with a certain degree of confidence. These features suggest a distant source and indicate that the specimen was deliberately transported to the Armea settlement during Roman times. The mode of preservation of the specimen is, in this regard, comparable to some trilobites recovered from fossiliferous localities in the Aragoncillo inlier of the western Iberian Range (Province of Guadalajara), as well as from the southern part of the Spanish Central Iberian Zone (Provinces of Ciudad Real and Badajoz) (Fig. 7). No sites outside Iberia are known to have yielded Ordovician trilobites with comparable preservation.

The nodules with *Colpocoryphe* from the Sierra de Aragoncillo (1 in Fig. 7) were first illustrated in the 18th century (Torrubia 1754), though initially misidentified as a species of crab. A recent review of trilobite assemblages from the inlier identified two sites with *C. grandis* specimens preserved as iron oxide casts in the municipalities of Pardos and Aragoncillo (Romero and Gutiérrez-Marco 2021; their fossil localities PS-I and CR-VII, respectively). The specimens at these sites were recovered from nodules within mudstones of the upper Villar del Salz Formation. However, unlike the Armea specimen, these show no advanced weathering and rubefaction that would result in a similar reddish hue.

Fossiliferous nodules containing trilobites and various invertebrate groups are relatively common in the Middle Ordovician shaly formations collectively referred to as the 'Tristani Beds' of the southern Central Iberian Zone (Gutiérrez-Marco et al. 2002), see areas marked in black on Fig. 7. These argillaceous shales extensively outcrop along the flanks, or in the core, of large Variscan synclines with Appalachian-like geomorphology (elongated erosional landforms), though with much simpler internal structure. Some areas along these synclines retain Plio–Pleistocene cover, preserving the underlying original dark shales and their nodules as weathered yellowish, pink or reddish impure claystones masses. This deep, penetrative weathering or palaeo-alteration, which extends 3 to 5 m below the current surface, dates from a Neogene phase of extreme aridity. The weathered shales have long been used since antiquity as a source for clay roof tiles. In both former quarries and natural outcrops of these discoloured rocks, the nodules and isolated fossils within them—mostly casted in iron—have differentially resisted palaeo-alteration processes and show a rubefied, reddish appearance.

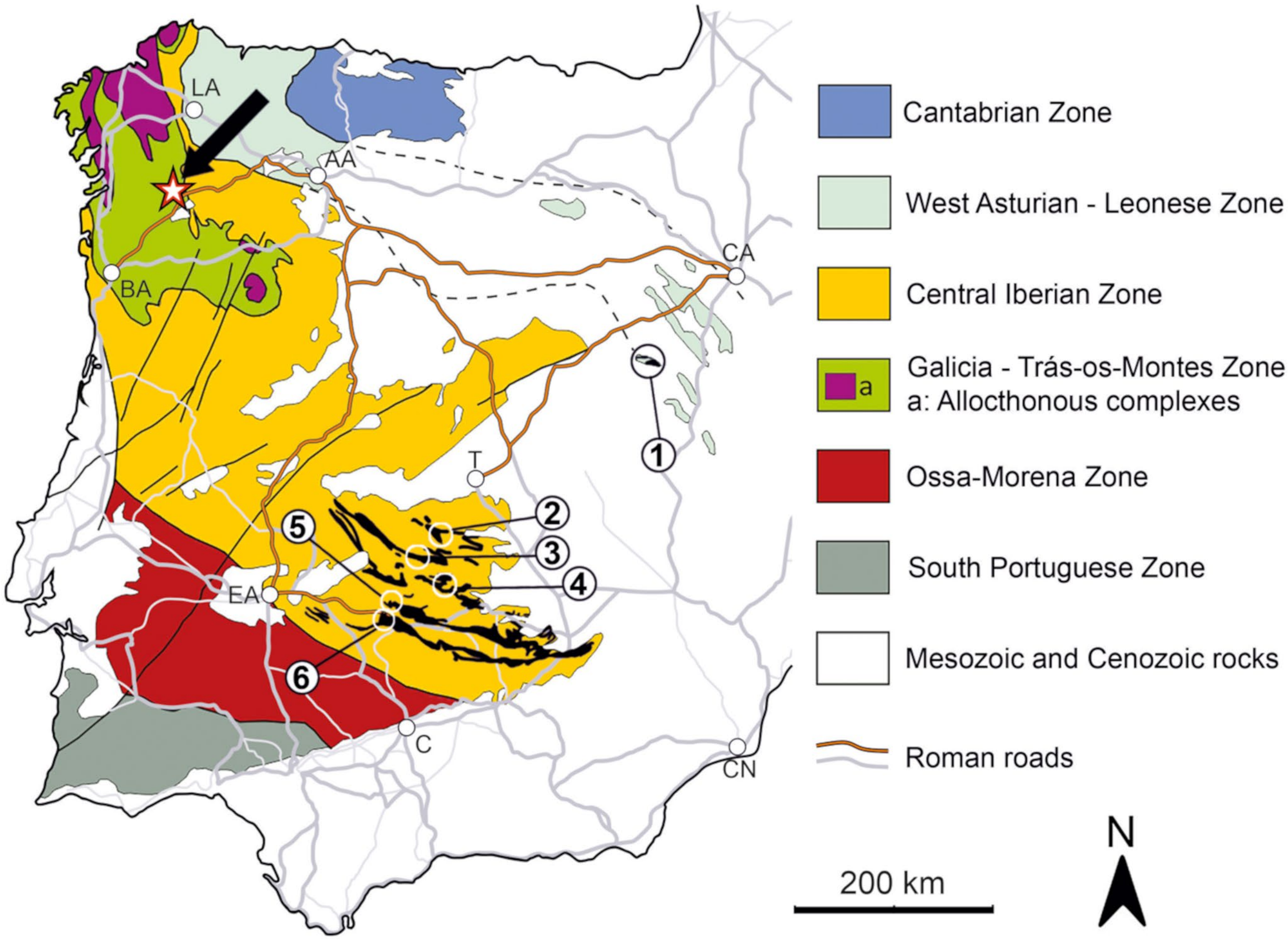

Fig. 7 Map of the Iberian Peninsula and possible source areas of the fossil trilobite transported to the Armea Roman settlement in NW Spain (= star, arrowed). The Geological sketch map shows the Variscan zonation of the Iberian Peninsula. Position of Ordovician outcrops with the 'Tristani Beds' of suspected provenance are indicated in black and numbered (see below). A map of the Roman roads according to Antonine Itinerary is superimposed on the base map, in order to show the hypothetical main transport routes (highlighted in orange) of the trilobite fossil to the Armea settlement. Possible source areas of the fossil: 1, Aragoncillo Massif, Western Iberian Ranges (province of Guadalajara); 2, Navas de Estena and Ventas con Peña Aguilera synclines, central Toledo Mounts (provinces of Toledo and Ciudad Real); 3, southern branch of the Guadarranque syncline (province of Ciudad Real and Badajoz); 4, El Chiquero–Luciana area, southeastern Puebla de Don Rodrigo syncline (province of Ciudad Real); 5, Garlitos–Alisedas, nothwestern end of the Almadén syncline (provinces of Badajoz and Ciudad Real); 6, Peñalsordo–Guadalmez area (provinces of Badajoz and Ciudad Real). Roman cities: AA, *Asturica Augusta* (Astorga); BA, *Bracara Augusta* (Braga); C, *Corduba* (Córdoba); CA, *Caesar Augusta* (Zaragoza), CN, *Cartago Nova* (Cartagena); EA, *Emerita Augusta* (Mérida); LA, *Lucus Augusta* (Lugo); T, *Toletum* (Toledo). The Roman road today known as the 'Vía de la Plata' (Silver Way) connected *Asturica Augusta* with *Emerita Augusta*, and its route is replicated by modern highways

The taphonomic features and rubefaction observed in the Armea specimen are consistent with trilobites from numerous fossiliferous 'Tristani Shales' sites (including the Río, Navas de Estena, Guindo, and Cantera formations) that exhibit 3D preservation and palaeo-alteration, which also differs markedly from other trilobite occurrences in southwestern Europe and North Africa. These Central Iberian sites are located within the synclines of Navas de Estena, Guadarranque (south-eastern part), Puebla de Don Rodrigo, Corral de Calatrava, Almadén, and Guadalmez, with examples including localities mentioned by Rábano as NE-V and RE-VII (2 in Fig. 7), RA-I (3 in Fig. 7), PI-III (4 in Fig. 7), and AM-I (5 in Fig. 7). Additionally, numerous unnumbered sites, explored by one of the authors (JCG-M) over the last 35 years whilst preparing the official 1:50 000 Geological Map of Spain, have yielded iron-cast *Colpocoryphe* specimens preserved in full relief, similar to the Armea specimen and showing comparable rubefaction due to a geochemically similar environment. Evidence of this process can be seen in the alteration halo on the specimen's left-hand underside (Fig. 1a.2) and in the yellowish, sericitic clays preserved within the inter-annular spaces of the first three segments of the specimen, from rings seven to nine of *Colpocoryphe*'s thorax.

Based on the specimen's taphonomic imprint, taxonomic identification, and compatibility with certain fossiliferous sites across Iberia, Fig. 7 suggests possible origin areas for the Armea trilobite. The first possibility lies in the western, or Castilian, branch of the Iberian Range, approximately 500 km from Armea (1 in Fig. 7). This origin seems less likely, given the relative scarcity of fossil localities with iron-cast reedocalymenine fossils and the lower degree of rubefaction. The second, more probable source is a highly weathered Neogene palaeo-alteration site within the Central Iberian Zone of western Spain, likely in eastern Badajoz province or in the western and southern regions of the Ciudad Real province. This alternative suggests a minimum linear distance of around 430–450 km to Armea from eastern Badajoz or the central Montes de Toledo (2–3 in Fig. 7), or up to 530 km from southwestern Ciudad Real (4–6 in Fig. 7).

In any case, what is absolutely certain is that the mode of preservation of this *Colpocoryphe* specimen excludes a nearby origin within the Roman province of *Gallaecia* and strongly suggests derivation from Ordovician outcrops in the southern Central Iberian Zone.

Trilobites in archaeology

Invertebrate fossils are well-documented from numerous archaeological sites across a wide range of ancient to modern cultures (e.g. Oakley 1978, 1985; Bassett 1982; Mayor 2005, 2023; Forli and Guerrini 2022; Romano 2024; Meier et al. 2024). However, trilobites—and Palaeozoic fossils in general—are relatively rare in archaeological records, largely because they are typically found within hard rocks (e.g., shales, sandstones, recrystallized limestones) that resist decomposition through weathering. As a result, these fossils undergo the same weathering processes as their host rock and are rarely exposed at the soil surface. Consequently, most Palaeozoic fossil finds at archaeological sites have been incidental, often due to their presence in lithic material used for artifacts (e.g. Key et al. 2014).

The earliest recorded discovery of a trilobite in an archaeological context was in 1886, in a cave next to the Cure River in north-central France, later known as the 'Grotte du Trilobite' (Salmon 1889; Parat 1902). This cave, located in the Arcy-sur-Cure area (Yonne Department, Bourgogne–Franche-Conté region) is well known for its rather continuous archaeological record from the Mousterian to Magdalenian periods, making it a key European Palaeolithic site (e.g. Breuil 1914; Leroi-Gourham 1951; Schmider et al. 1995; Mevel 2013; Malgarini et al. 2017; Sécher 2020). The famous trilobite from this site is an eroded, prone articulated thorax and pygidium with two lateral circular perforations, suggesting it was used as a pendant (Fig. 9a–c). It was found in the Magdalenian layer (bed 5), dating to the Older Dryas (a cold stadial ca. 14,000 years BP, late Pleistocene), alongside hundreds of flint artifacts, a few spearheads, various equid and cervid bones, and several pierced pendants such as a wolf tooth, some seashells, and a carved buprestid beetle made of lignite (Salmon 1889, 1891; Schmider et al. 1995). H. Douvillé initially identified this trilobite (Salmon 1889) as the Phacopid '*Dalmanites*' *hawlei* Barrande (Barrande 1846), a species from the Upper Ordovician of Bohemia later reassigned to *Zeliszkella hawlei*.

Despite its geographical restriction to the Prague Basin, nestled in the eastern reaches of the Magdalenian culture, the fossil was considered as likely derived from some unspecified location in central Germany, about 2000 km from the Trilobite Cave. An obviously wrong deduction, since its distance to Prague, even further east, is ca. 830 km. The original drawings of the trilobite (Salmon 1889; 1891; Fig. 8a, c) were profusely reproduced in subsequent publications (e.g. Oakley 1965, 1971, 1978; Bassett 1982; St. John 2007; Conneller 2014) with a single known photograph (Schmider et al. 1995) (Fig. 8b). This shows a strongly abraded and almost indeterminate specimen, which was doubtfully attributed to a different Phacopid genus (*Kloucekia*? sp.) by R.A. Fortey (Oakley 1978) or as a Zelliszkellinae *sensu lato* by J.-L. Henry (2001), without ruling out in both cases their origin from some unknown French site.

The controversy created by the resurrection of the oldest interpretation (*D.*? *hawlei*, assigned to the 'Silurian') (Oakley 1999; Sequeira Fernandez 2005) motivated new comments by palaeontologists (Chlupáč 2000; Henry 2001), who made it clear that the trilobite is an Ordovician zelliszkellinid that could well have come from a locality in France instead of Germany. Despite its poor preservation, it probably belongs to the genus *Ormathops* owing to the outline of the subtriangular pygidium and the elongation and backward curvature of the tips of the posterior thoracic pleurae (Fig. 8a–c). Besides this, Henry (2001) indicates that this 'trilobite amulet' could have originated from the Ancenis region (south-east of the Armorican Massif), near the Loire River, where fossiliferous nodules included in Middle Ordovician shales yielded a rather similar representative of *Ormathops* (Henry et al. 1997). This implies that the transport of the trilobite in Late Palaeolithic time could have been around 370 km away, rather than the 800–2000 km previously suggested.

The following prehistoric trilobite finds were located in three Middle to Later Stone Age rock shelters in the Western Cape Province of South Africa (Helm et al. 2019). They represent allochthonous manuports from areas either close to the sites or at a distance of at least 10 km.

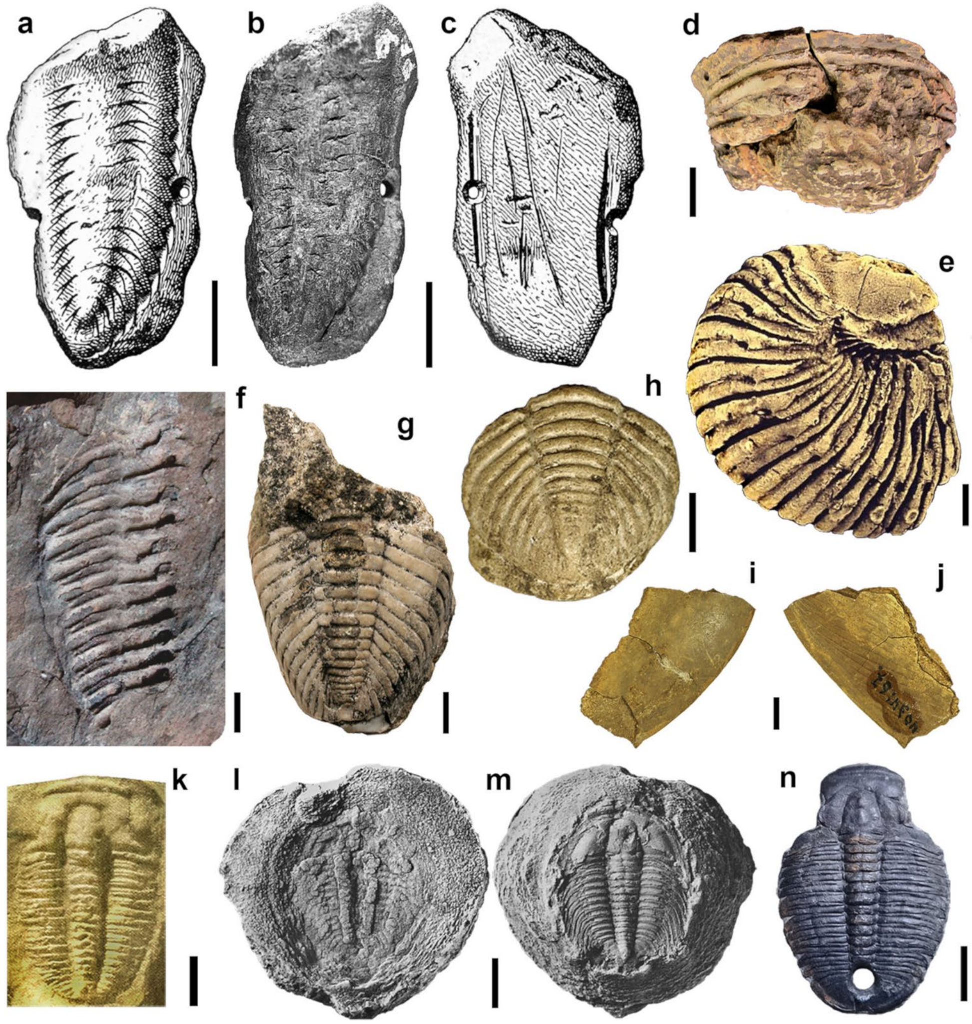

Fig. 8 Summary of the world trilobite record related with archaeological sites. **a − c**, Thorax + pygidium of *Ormathops*? sp., from the 'Grotte du Trilobite' of Arcy-sur-Cure, France, Magdalenian, Late Palaeolithic: idealized drawings of both sides (**a**, **c**) and photograph of the specimen (**b**). **d**, Thoracic fragment of *Burmeisteria*? sp. from Klipfonteinrand rock shelter, South Africa, Middle Stone Age. **e**, Enrolled juvenile specimen of *Burmeisteria herschelii* (Murchison 1839) from Vleiplaas OP10 shelter, South Africa, Later Stone Age. **f**, Articulate thorax of *Bainella* sp. from Cave 17/Robberg Peninsula, South Africa, Middle–Later Stone Age transition. **g**, Pygidium of *Toxochasmops vormsiensis* (Rõõmusoks 1998) from Pirmastu Middle Age cemetery, Estonia. **h**, Pygidium of *Valdariops* cf. *eichwaldi* (Schmidt 1881), from Mustivere settlement, Estonia, Viking to Late Iron ages. **i − j**, Unidentified? asaphid pygidial right pleural border, in dorsal (i) and ventral (j) views, from Koila hillfort, Estonia, Pre-Roman Iron Age or younger beds. **k**, *Lyriaspis airoiensis* (Etheridge 1919), cast of the external mould of a complete specimen detached from an old aboriginal artefact, east of Alroy Downs, Northern Territory, Australia. **l − m**, Central part of a calcitic nodule (l, lower surface; m, upper surface) bearing a complete specimen of *Aphelaspis westropi* (Chatterton and Ludvigsen 1998), Coast Salish site, British Columbia, Canada, pre-Columbian Northwestern Coast tribes. **n**, Drilled specimen of *Elrathia kingii* (Meek 1870), from an undated old tomb of the Pahvant Ute tribe, Sevier Valley, west-central Utah. Scale bars, 10 mm (a–c, f–g, l–m) and 5 mm (d–e, h–j, n) [1].

[1] Repositories and source of illustrations: **a − c** in Adrien J.-F. Ficatier coll., Jean Després Avallonnais Museum, Avallon, France (inv. nr. T.F-9); drawings are from Salmon (1891, pl. 17, Figs. 5 − 6); photograph reproduced from Baffier (in Schmider et al. 1995; Fig. 25). **d** in the University of Cape Town, South Africa (unnumbered specimen); photograph reproduced from Helm et al. (2019; Fig. 8a). **e** in Council for Geoscience, Bellville, Cape Town, South Africa (coll. nr. B 472); photograph by J. Almond, reproduced from Helm et al. (2019; Fig. 5). **f** housed either at the African Centre for Coastal Palaeoscience, Gqeberha, or the Evolutionary Studies Institute, Port Elizabeth, South Africa (unnumbered specimen); photograph reproduced from Helm et al. (2019; Fig. 13b). **g** in Viljandi Museum, Viljandi, Estonia (VM 8873), from Johanson (2018a; Fig. 9.1). **h** and **l − m** in Archaeological Research coll. of Tallinn University, Estonia (AI 3993: 204 and AI 4034, respectively); h from Johanson (2018a; Fig. 9.2); l − m unfigured specimen in the same paper (photos provided by K. Johanson). **k** in Australian Museum, Sydney, Australia (plaster cast L1344), from Mitchell (1922, pl. 54, Fig. 11). **l − m**, unnumbered specimen belonging to the Stó:lō Nation archives, Sardis, Chilliwack, Canada. **n** in American Museum of Natural History, New York (A. Secher coll., Museum's photo).

The first of these trilobites comes from the Klipfonteinrand rock shelter, located in the eastern Cederberg Mountain. It was discovered by Mackay (2012; see Helm et al. 2019, p. 549) in a Middle Stone Age deposit (~60,000–65,000 years BCE), and identified by John Almond as a complete *Burmeisteria* sp. The probable source of the specimen is a nearby outcrop of the Early Devonian Gydo Formation of the Bokkeveld Group, situated approximately 400 m from the shelter. Judging by the only available photograph (Fig. 8d), the visible features consist of a few transverse elements that might correspond to a portion of the thorax of a homalonotid trilobite, rather than a complete specimen—unless the image shows a partial view of an enrolled individual.

The second of the South African trilobites comes from a small shelter catalogued as 'Cave 17', located on the Robberg Peninsula on the southern Cape coast. It was found on the surface but accompanied by ochre pieces, pointing to a timespan corresponding to the Middle–Later Stone Age transition (MacKay 2012; Helm et al. 2019). It consists of an articulated thorax preserved in a piece of rock matrix that is easily portable (~600 g), and has been identified as *Bainella* sp. (Fig. 8f). This genus is represented by two species with identical thoracic morphology, known from the Emsian Gydo Formation. The nearest exposures of this formation lie at a linear distance of 10 to 25 km along the coast from Cave 17.

The third of these South African trilobites is an enrolled juvenile specimen of *Burmeisteria herschelii* (Murchison 1839), preserved in a phosphatic nodule, originating from the OP10 shelter at Vleiplaas, in the Agterpakhuis area of the northern Cederberg Mountain (Fig. 8e). It was discovered by Miller et al. (1990), accompanied by quartz crystals, mineral pigments, and stone tools, in a context characteristic of the Later Stone Age (~40,000–50,000 years BCE). The trilobite originates from the Lower to Middle Devonian Bokkeveld Group, the nearest outcrops of which are located 10 km to the north and east of the Vleiplaas rock shelter (Helm et al. 2019). According to MacRae (1999, pp. 2–3), the fossil was most probably regarded as a special object by Stone Age people, and may have been used either for ornamental or ritual purposes.

The following group of trilobite finds comes from three archaeological sites in south-central Estonia (Johanson 2018a). These consist of two Phacopid trilobite pygidia preserved in limestone and one detached pygidial fragment showing both its dorsal and ventral surfaces (Fig. 8g–j).

The first specimen (Fig. 8h) was found at the Mustivere settlement site, where Late Iron Age and Viking occupations have been documented (Johanson 2018a). The fossil was found in an occupation level excavated in 1948 and dated between the 8th and 13th centuries CE (Tvauri 2002). According to H. Pärnaste (written comm., February 2024), it could be identified as *Valdariops cf. eichwaldi* (Schmidt 1881), a species ranging from the Vormsi to Pirgu regional stages of the Upper Ordovician series (Rõõmusoks 2000). The second Estonian specimen (Fig. 8g) comes from the Medieval cemetery site in Pirmastu village (Johanson 2018a). It was collected there by schoolchildren together with a few coffin nails, a finger-ring and some copper coins, but as it was not found in direct association with any burials, its interpretation remains uncertain (Johanson 2018a). H. Pärnaste (written comm., February 2024) identified this pygidium as belonging to *Toxochasmops vormsiensis* (Rõõmusoks 1998), an Upper Ordovician species from the Vormsi regional stage.

Finally, the third Estonian trilobite is an unidentified fragment, cited but not figured by Johanson (2018a), which comes from the Iron Age Koila hillfort settlement, dated from 5−6th century until the end of the 1st millennium CE, but habited also in Pre-Roman Iron Age time (500 BCE to 50 CE): Johanson (2018a). In this case, we have no further information on the context in which it appeared. The specimen has been examined here and clearly corresponds to the thickened pleural right border of the pygidium of an Ordovician? asaphid trilobite, showing a smooth dorsal surface and a large ventral doublure with prominent oblique terrace ridges (Fig. 8i–j).

The record of these trilobite remains about 90–100 km south of the Ordovician outcrops located around the northern coast of Estonia, does not indicate intentional transport by ancient human populations, but rather that they were derived from Ordovician limestone pebbles transported southwards by Pleistocene glaciers and collected from the nearby moraines and other glacial sediments. Apparently, none of the three specimens show visible marks of use or anthropogenic modification, so they could represent archaeological evidence of fossil collecting. Their nature could vary from simple objects that captivated attention as curiosities to take home, to the recognition and belief in lithified animals, which could provide magical or apotropaic use (Johanson 2018a, b). In the same sense, the pygidium with the very smooth surface found in Mustivere (Fig. 8h) could have been used as a talisman worn in a pocket or a pouch (Johanson 2018a).

In addition to the lack of anthropic modification, all three cases have clear dating issues, as they are situated within very broad and general contexts ranging from the middle of the first millennium BCE to the medieval period, and therefore cannot be compared with the trilobite studied in this paper.

Other trilobites found associated with past human cultures are from the Cambrian, originating from North America and Australia, and can also be classified as anthropological cases. The oldest of these is linked to early native populations in southwestern Canada. Between hundreds and 3000−4000 years ago, a specimen of the late Cambrian trilobite *Aphelaspis westropi* (Chatterton and Ludvigsen 1998) was transported in a nodule (Fig. 8l–m) to an archaeological site along the Fraser River in southwest British Columbia, where it was found with knives, points and scrapers of basalt and nephrite. This implies a transport of about 450–500 km east of the Fraser River, because the trilobite species and its peculiar calcitic preservation is currently known only from a site along Tanglefoot Creek in southeastern British Columbia (Chatterton and Ludvigsen 1998; Ludvigsen and Pugh 1995; Ludvigsen 1999, 2003; Nisbet 2003).

A second Cambrian trilobite was recorded in the Barkly Tableland, Northern Territory, Australia (Fig. 8k), occurring on the surface of a worked chert implement of an aboriginal artifact of unknown age (Etheridge 1919; Mitchell 1922; Whitehouse 1939; Oakley 1971), but probably belonging to some early Yindjilandji tribe from several thousand years BP. It corresponds to the external mould of a complete specimen of the species *Lyriaspis airoiensis* (Etheridge 1919), and the transport involved for the artifact was estimated to be only about 5 km from the middle Cambrian locality of probable provenance (Whitehouse 1939; St. John 2007).

The most modern record of a trilobite found in an archaeological context refers to a drilled specimen of the Ptychoparioid *Elrathia kingii* (Meek 1870) (Fig. 8n), a common late middle Cambrian species in the House Range of Utah, USA. This particular specimen was discovered in a Pahvant Ute Indian tomb of undetermined age, excavated in the early 1900s in the Sevier Valley of west-central Utah (Taylor 1976; Kennedy 1976; Oakley 1985; Mayor 2005). Oral traditions from the tribe suggest trilobites were valued as protective amulets, likened to 'lizard foot bead things' and 'little water bugs in stone houses', which suggests that they thought they could even be petrified arthropods (Taylor 1976).

Cryptopalaeontological references to trilobites

To the trilobites recorded from archaeological sites in all continents, which totalled only ten specimens until the present discovery, within the wide range from the Late Palaeolithic to the American pre-Columbian or the early aboriginal Australian times, we must also add the data derived from cryptopalaeontology (Liñán and Gozalo 2008). This emerging discipline (Liñán 2004; Liñán et al. 2013) seeks to associate contemporary nomenclature with all classes of geological objects cited in ancient pharmacopoeias and lapidaries, in which, despite the lack of illustrations, some of these references must, at least in part, have corresponded to trilobites. The relationships between them are based both on the interpreted morphology of the objects and on references to their places of origin. The clearest examples related to these fossils come from China (Oakley 1978; St. John 2007; Peng 2007; Forli and Guerrini 2022), where pygidial axes of trilobites, either isolated or with the pleural fields obscured by matrix, were cited as 'stone silkworms'. This name appears in the 'Kaibao Benchao' pharmacopoeia (printed in 973 CE), but probably it was already included in the earlier 'Xinxiu Benchao' pharmacopoeia (ca. 659 CE), which was hand-written and has been preserved incomplete (Peng 2007). A similar case concerns the rocks containing trilobites known as 'bat stones', traditionally used to make inkstones in Chinese calligraphy. The name derives from the frequent occurrence of the late Cambrian trilobite *Neodrepanura premesnili* (Bergeron 1889), represented by isolated sclerites with large anterolateral pygidial spines, which show some resemblance to flying bats (Peng 2007). The 'stone bats' are mentioned frequently in ancient Chinese literature, especially in Shandong and southern Liaoning provinces where the Kushan Formation crops out, very fossiliferous and rich in this Damesellid trilobite. Even the co-occurrence of 'stone bats' and one 'stone silkworm' in the same rock surface was cited in the 17th century (Peng 2007). The 'stone bats' from the same Chinese localities are also currently known as 'butterfly stones' (Taylor 2017).

In addition to the previous Chinese references, some authors interpreted that in classical Greek and Roman antiquity trilobites would have been mentioned in diverse lapidaries under the names 'scorpion stones', 'ant stones' (=*Myrmecias* or *Myrmecitis* Stone) or 'beetle stones' (=*Cantharias* Stone), assigning them various preventive or curative properties (Liñán and Gozalo 2008). However, as indicated, the morphological or colouration comments accompanying these objects are too vague to allow any of them to be interpreted as trilobites with any certainty.

Discussion

Transport of the fossil by Romans to the Armea settlement

The most probable area of origin for the fossil, estimated at around 430–530 km in a straight line from A Cibdá of Armea, was located in the central region of the Iberian Peninsula; an area that in Early Roman times belonged to the ancient province of *Lusitania*. Figure 7 illustrates the main roads existing during the Early Roman times, which would have increased the total distance of the fossil's journey, as none offered a direct connection with the potential fossil sites. However, all are located relatively close, to the west, to the main land route linking eastern Andalusia with the northwest of the peninsula. This ancient imperial road connected *Emerita Augusta* (Mérida) with *Asturica Augusta* (Astorga) and remained in operation throughout the first millennium BCE as the primary north-south communication route across Iberia (Rodríguez-Corral and Rodríguez-Rellán 2023).

Upon reaching *Asturica Augusta*, several roads extend from this city (roads XVII and XVIII of the Antonine Itinerary) toward southern *Gallaecia*, passing close to Armea (Fig. 7). Consequently, it is reasonable to infer that the Armea trilobite reached its destination along this primary south-north route, traditionally associated with the transport of tin and other metals from mines in the northwest to ports in the south of the peninsula (*Hispalis*/Seville, *Onuba*/Huelva or *Gades*/Cádiz), from where goods would be shipped to the eastern Mediterranean. Its potential link with metal trade becomes apparent, as Armea prospered in the 1st to 3rd centuries CE as a small city whose wealth was bolstered by the nearby Monte Medo mine (Fernández Fernández and Pérez Losada 2017). This was an open-pit silver and tin mine exploited during the Early Empire (Sánchez Palencia et al. 2009).

The trilobite could have travelled with metals and other goods as a unique and exclusive object, valued in *Gallaecia* for its protective and healing properties. Alternatively, it might have arrived in the possession of someone from central *Lusitania* in the 1st century CE, seeking to settle in this region. This period saw significant economic growth that attracted people from other areas, many from the imperial administration itself, to govern, administer, and exploit a new territory that possessed rich mining and metallurgical resources.

Use and function of the fossil

As mentioned in the introduction, both classical sources and recent studies indicate that fossils were used in antiquity essentially as magical and protective objects. The Armea trilobite fragment unquestionably shows evidence of anthropic work, particularly on the underside and left side of the piece (Fig. 2). These marks do not affect the upper surface, which displays the characteristic articulated segments of a trilobite's dorsal exoskeleton. It seems clear that the person who modified the stone intended to leave that natural surface untouched, while simultaneously adapting the fossil to its new function.

The subcircular contour and polished lower surface of the trilobite specimen firstly suggests a possible use as a stone token (*calculum*) for games such as *ludus latrunculorum* or *terni lapilli* (Austin 1935; Parlett 1999; Bell 2010). Some Roman *calculi* made from mammoth tooth, for example, have been found at Opatów, Poland (Madyda-Legutko et al. 2000). Other fossil material from the Roman period classified as potential game tokens includes a Jurassic brachiopod from a grave at the Weklice necropolis, Poland (Skóra 2021) and, more convincingly, two Cretaceous brachiopods (*Chatwinothyris*? sp.) from an elite grave in northeast Jutland, Denmark (Hedeager and Kristiansen 1981; Lund Hansen 1987). In the case of these terebratulids, both valves display signs of abrasion, possibly indicating active use. However, the more common archaeological record for tokens of these Roman games consists of stone pebbles, polished bones, and ceramic pieces, typically larger and with a smoother, less complex ornamentation than that of the fossil under study.

Despite the absence of holes or perforations, a likely hypothesis is that the trilobite could have been set as part of a necklace (Fig. 9c–e) or bracelet (Fig. 9, a–b), similar to trilobite records from a European Palaeolithic site and ancient American tribes (Fig. 8a–c, n). These rare trilobite specimens display perforations, suggesting their use in a necklace or possibly as part of a composition with other beads. In the case of our specimen, a crimp or cabochon could have encased the lower and lateral areas, leaving the upper part visible, thus allowing the fossil to be recognised as an ancient creature or simply an intriguing ornamental stone (Fig. 9a–b). The setting material may have been either organic (leather?) or metallic. The former would not have been preserved due to rapid decomposition in acidic soil, while if it were a valuable metal like silver or gold, it would likely have been reused or recycled before the stone object was discarded.

Our second hypothesis is that the trilobite may have been modified to be integrated into a necklace as a banded pendant with a metallic mount (Fig. 9c–e). Supporting this interpretation are examples of banded pendants from the Roman Empire and *Barbaricum* sites, incorporating Mesozoic belemnites (Schuster 2004) and bivalves (Socha and Sójkowska-Socha 2012), fossil corals (Skóra et al. 2021), small sea urchins (Blinkenberg 1911; Kuchenbuch 1938; Stanek 1999) or shark teeth (Schuster 2010). As suggested in the previous interpretation, if the fossil had a metal mount, it would likely have been retrieved before disposal. The find location, a city rubbish dump, also makes accidental loss improbable if it had been mounted with leather bands, animal tendon, vegetable cord as the crafted underside of the fossil was designed to be mounted as part of an unknown object (necklace, bracelet or others). It was also possible that the trilobite was carried in a bag or pocket.

Nevertheless, regardless of how the trilobite may have been mounted or not, it was certainly intended to serve one of the potential functions outlined above; as a magical, propitiatory, and apotropaic object (as a talisman or amulet with a supernatural purpose), or even as a medicinal

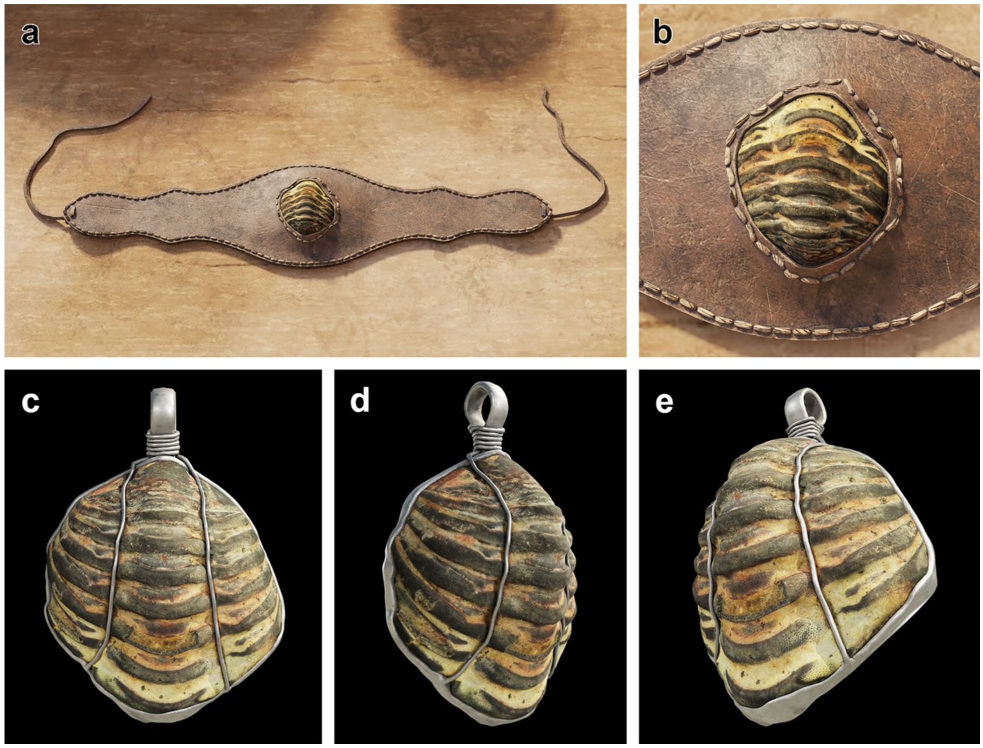

Fig. 9 Computer simulations of the Armea trilobite specimen mounted for use as a personal ornament. **a**–**b**, Leather bracelet with the trilobite attached via a central hole, sewn to an additional leather piece on the reverse (detail in b). **c**–**e**, Different views of the same specimen, set in a banded pendant of silver or another metal

item according to the cryptopalaeontological theory on trilobites (Johanson 2018a). As already suggested (Johanson 2018a, b), the rarity and mysterious origins of invertebrate fossils in classical archaeology contributed to their perception as extraordinary objects, a trait ideal for signifying social status. This would explain their association with elite graves around the *Barbaricum* territory during the Roman period, and also their sparse appearance in domestic excavations such as the Armea settlement, where they likely held magical significance. This may include votive offerings or 'foundation offerings' placed within settlements in Scandinavia, notably within privileged houses to the Viking-period homes (Søvsø 2017).

While a trilobite like the one found in Armea may have been perceived as a lithified animal and gathered as an apotropaic item, we cannot exclude its use as a simple decorative bead, adorning the body of its owner. The aesthetic appreciation of Romans for transversely grooved forms, such as the segments of a trilobite thorax, is demonstrated in certain necklace beads made from black glass and jet, previously called 'channeled beads' or 'grooved beads' in archaeological literature, now classified as *Trilobitenperlen* (Haevernick 1974; Cosyns 2012) (Fig. 10). The author of this iconic name (Haevernick 1974) states that is simply because this type of beads resembles fossils of the extinct arthropod but it is uncertain where they result from direct imitation, given the lack of evidence for awareness of such fossils in ancient contexts and the absence of their use as beads or necklaces (Haevernick 1974). This term replaces the name 'channelled beads' or 'grooved beads' which the author considers overly generic. Most researchers regard these glass beads as a 'cheap' imitation (Cosyns 2012) of similar jet beads. Those recovered in Cologne and made of jet are noted for their resemblance to the upper part of the thorax of trilobites (Hagen 1937) (Fig. 10b). Jet itself is not a particularly precious material, but its importance lies in its magical and therapeutic qualities (Storti 1996). Such accounts are very common throughout the Roman era, and Hispania is no exception, with these beads found throughout in contexts from the 2nd to the 4th–5th centuries CE. However, so far, only black glass *trilobitenperlen*, not jet ones, have been identified in Hispania (Menéndez Menéndez 2023) despite the presence of significant deposits of this fossil stone in the Iberian Peninsula and the numerous artefacts crafted from jet, which often form part of bracelets. In contrast, black glass beads could also be used in necklaces and combined with beads made from other materials, such as semi-precious stones, metals (bronze or gold) and, notably, another fossil material with protective and healing properties: amber. We know of a significant glass workshop in *Bracara Augusta* (Braga) that produced this type of beads along with numerous black glass objects, supplying the entire northwest in the late antiquity period (Da Cruz 2009). This practice of making copies of fossils in antiquity is not entirely new. Marine fossils were replicated in China in the early 5th century CE (see Chap. 17

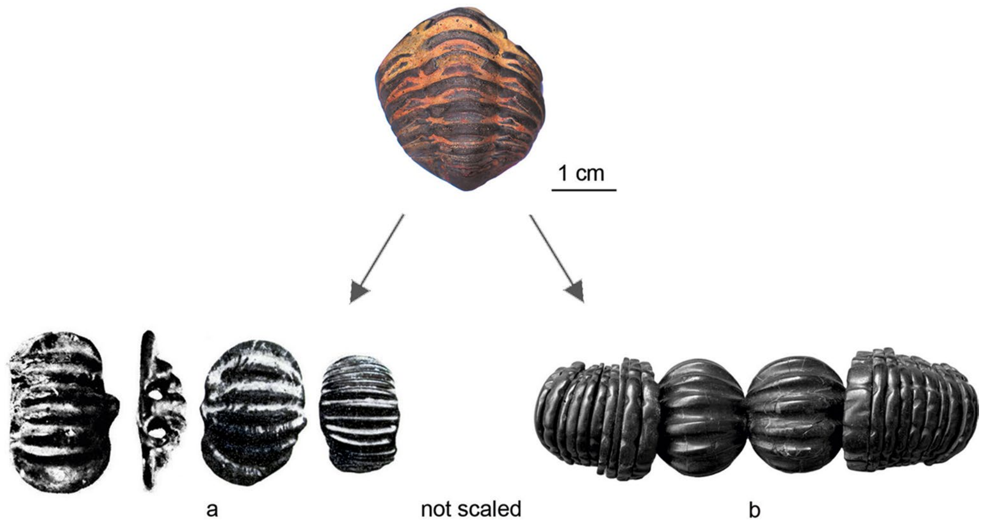

Fig. 10 Comparison of Armea's trilobite with Roman *Trilobitenperlen* (necklace beads). **a**, *Trilobitenperlen* in black glass, Dunaújváros, reproduced from Haevernick (1974; Fig. 1). **b**, *Trilobitenperlen* in jet, Cologne, c. 3rd–4th CE: Römisch-Germanisches Museum coll., Cologne, Germany, Inventar-Nr. N 5165 (Photo: Helga Schmidt-Glassner, © Bildarchiv Photo Marburg)

in Mayor 2022) and numerous examples of fossil replicas in prehistoric archaeological contexts are known from Malta (Mayor 2023).

Paradoxically, *trilobitenperlen* beads have yet to be found in Armea, either in black glass or, naturally, in jet. However, there we find the possible missing link to trilobite-shaped necklace beads, which may explain the existence of this jewellery tradition throughout antiquity. The similarities between jet *trilobitenperlen*, glass ones, and the Armea trilobite are significant, demonstrating that jet and glass craftsmen sought to faithfully reproduce the metameres of a trilobite's thorax, thereby endowing the new pieces (similar in shape, colour, and even in texture) with the qualities of the original material. This allowed them to protect the wearer from magical and religious threats or even to heal diseases. Materials like jet and glass were much easier to obtain than an 'authentic' trilobite and consequently became the preferred material for this type of bead throughout antiquity, particularly from the 3rd century onwards, with the expansion of jet objects from the sites at York, Britain (Allason-Jones 1996).

Trilobites and other fossil stones could fall under the ancient definition of *gagates*, a group of black and greyish coals and raw materials used as amulets, that may include obsidian, black coral, jet, and even amber (Menéndez Menéndez 2023). Objects made from these materials have also been associated with the world of death, as they systematically appear in funerary contexts, accompanying the deceased as part of their burial goods; these qualities were soon adapted by Christianity—at least in Braga (Da Cruz 2009). This same association with the world of death is also found in a brachiopod shell documented in a Roman-era tomb in Weklice, Poland (Skóra et al. 2021). Despite using these 'magical' raw materials, the arrival and expansion of Christianity marked the end of the manufacture of *trilobitenperlen*.

The discovery of the trilobite fossil in the Armea archaeological complex is not entirely surprising in a location steeped in various legends and traditions. Ritual activity is attested at the site from before the Roman period, and archaeological remains have become intertwined with these legends. Traditional accounts associate the city with the martyrdom of Saint Mariña, a legend dating back to the 2nd century, and numerous archaeological remains scattered throughout the A Cibdá of Armea are being Christianised through their incorporation into this martyrial narrative (Fernández Fernández 2017; Blanco-Rotea et al. 2015; Ferro-Vázquez et al. 2021).

Lastly, we would consider that the archaeological record where the Armea trilobite was recovered offers no information about its owners. We can hypothesise that, once discarded in a rubbish dump, the trilobite had lost its function and significance. It's also possible that it ended up there through accidental loss. However, this context is connected to an urban, domestic environment, a part of the city containing large houses where affluent families lived. This deposit is associated with the large northern house, known as the Hexasquel *domus*, a residence with an atrium, courtyard, two floors, and areas dedicated to wine production and social spaces (evidenced by a large *oecus-type* hall). Clearly, this is a high-status household, possibly with servants. Thus, the fossil likely belonged to one of its residents or to the family as a whole, serving as a unique element–petrified remains of an ancient animal with protective functions. Close to the find spot, a partially preserved inscription reading 'MAXSIMVS' was discovered on a courtyard wall, which may suggest the presence of a domestic altar, such as those preserved in the courtyards of two other houses. The trilobite may have been part of this family *lararium* (=household shrine), functioning as a votive offering as a protective object for the home and family. However, the most probable interpretation is that a family member carried it as a personal object. A recent study on jet in Roman Hispania suggests, albeit tentatively given the difficulty of interpreting the archaeological record, that most of these amulets were used by women and children for prophylactic and apotropaic purposes (Menéndez Menéndez 2023). Ancient iconography and their consistent presence in funerary contexts link these materials– also currently in the peninsular territory– to the feminine and infantile sphere, directly associating them with protection and death. It is possible that the burial in Weklice containing a brachiopod shell as a grave good was that of a woman (Skóra et al. 2021), connecting the fossil from this same period with the female sphere.

Final remarks

Marine invertebrate fossils, and particularly trilobites, occur very infrequently in archaeology and are therefore even regarded as 'anomalies of the record' (Mayor 2023). Part of the extreme rarity of Palaeozoic trilobites can be explained by the fact that their remains do not detach easily from the hard siliceous rocks or massive limestones in which they are generally found, and thus they went unnoticed by many ancient collectors in past eras of humankind. Nonetheless, both in the ten preceding archaeological records of trilobites and in the eleventh global discovery detailed in this article, trilobites were attributed similar magical, protective, or even medicinal functions, akin to those found among other groups of invertebrates in archaeological sites from diverse epochs, myths, traditions, and ancient pharmacopeias.

The fact that small fossils were transported to archaeological sites over long distances, sometimes as unworked manuports like ammonites, belemnites, sea urchins, brachiopods, crinoid columnals etc. and other times selected primarily for use as beads, indicates that simple ornamental use was not the sole reason for their collection Oakley 1965; Rudwick 1985; Mayor 2005, 2023; McNamara 2010; Buffetaut 2017; Forli and Guerrini 2022; Romano 2024; Benoit et al. 2024; Navazo Ruiz et al. 2024).

The trilobite discovered at the Armea Roman settlement is a paradigmatic example of how a single artefact recovered in an archaeological context can significantly advance our knowledge of various aspects of antiquity. First, because there are no fossils of this type in the area or nearby regions, which are composed of igneous or strongly metamorphosed rocks. This supports the existence of a previously unsuspected trade of such pieces within the Iberian Peninsula, moving from south to north, over hundreds of kilometres to the find site, and linked in some way to mineral transportation routes. Secondly, the trilobite reveals that Romans already recognised the existence of ancestral animals in the subsoil, and these objects, understood in this way, were highly valued as 'sacred' with strong protective qualities. In this sense, the thoracic appearance of trilobites may have inspired an entire series of protective and healing objects, such as 'trilobite beads' made of jet, which were essentially used as protective elements by women and children.

The palaeontological analysis of the Armea trilobite has provided its taxonomic identification as a member of the Reedocalymeninae (*Colpocoryphe* sp.), age (453–460 million years, around the Darriwilian/Sandbian boundary of the Ordovician System), and origin area in the southern Central Iberian Zone of the Iberian Massif. The archaeological study has confirmed the collection and use of the trilobite fossil in the Roman period—possibly set in a bracelet or as a banded pendant in a necklace—, and dating the abandonment of the object to between the first and third centuries CE, although the exact purpose of its use remains somewhat speculative. However, it is plausible to consider that the Armea trilobite may have been perceived to hold magical and protective powers for its wearer, as is the case with fossils or even trilobites in other well-known archaeological contexts.

Our final consideration refers to a simple yet paradoxical historical coincidence: the Armea trilobite was found in archaeological level SU.204 alongside a bronze coin of Augustus, who, according to the Roman historian Suetonius (1997[ca. 70–post 126]), was a collector of fossils and founded the first known palaeontological museum.

Methods

The excavation of the Armea Roman settlement (Allariz region, province of Ourense, NW Spain), from which the studied specimen originates, has been carried out by the University of Vigo in annual campaigns since 2011 to the present, following a stratigraphic area excavation. Photographs for Figs. 2 and 9 were taken with a Canon EOS7D digital SLR camera equipped with a Canon MP-E 65 mm 1–5x macro lens. The originals from Fig. 2 were coated with magnesium oxide vapours before photography. Illustrations were composed and processed to homogenise light intensity across the figures using Adobe Photoshop CS3. All figures were drafted with CorelDRAW 12 (line drawings) and Adobe Photoshop CS3 (remaining illustrations). To create the optimized 3D model and the various hypotheses about the trilobite's use (Fig. 9), the programs Instant Meshes, Blender, and Adobe Photoshop were used. Photogrammetric 3D model of the fossil (Supplementary 3D Image) was made using a Canon PowerShot SX700 HS digital camera, mounted on a tripod within a lightbox with diffuse lighting. Images were processed with Agisoft Metashape software, resulting in a 1:1 scale digital twin of the trilobite fragment. This 3D model was exported in '.obj' format, accompanied by its texture in '.jpg' format and the '.mtl' file, which contains the material definition applied to the 3D object in its corresponding OBJ file.

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Author contributions AFF and JCG-M designed the research and wrote the paper with their co-authors; AFF, PVA, and AARN provided data on the archaeological context; JCG-M and Sara Romero provided palaeontological data; SR, PVA, AARN, and MG-A performed the figures, and MG-A performed the 3D image and video of the trilobite specimen.

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Data availability No datasets were generated or analysed during the current study.

Code availability Not applicable

Declarations

Ethical approval The submitted work follows the ethical guidelines of the journal. The authors declare that the manuscript is not in consideration for other journals, is an original work and was not probably published, there are no secondary publications, the results are presented clearly and honestly, and the data and theories presented are the author's own.

Consent to participate All authors agreed with the content and gave explicit consent to submit the paper.

Consent for publication All authors agreed with the publication of the content of the paper.

Competing interests The authors declare no competing interests.

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