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The Hoard of Rodotopi in Ioannina (Epirus, NW Greece) and the Copper Single-Edged Shaft-Hole Axes of the Early Bronze Age in the Helladic Area

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ABSTRACT
The Hoard of Rodotopi in Ioannina (Epirus, NW Greece) and the Copper Single-Edged Shaft-Hole Axes of the Early Bronze Age in the Helladic Area
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The hoard of Rodotopi in Ioannina is a set of four copper single-edged shaft-hole axes of the Early Bronze Age. Together with eight isolated similar artefacts from Epirus, they are classified in the type with the conventional name Veselinovo (after Vulpe). Its distribution is mainly located in the regions of Epirus, western-central Macedonia and in the neighbouring areas of Bulgaria or Romania. These were tools and/or weapons with a symbolic character, which were withdrawn from circulation (recycling) to become utilitarian or votive deposits. Furthermore, issues of production, consumption or use, combined with archaeometric data (metallography and chemical analysis), are examined to give a more comprehensive interpretation. This gives us an insight into the networks of ideas, commodities and know-how existing at an early period, when copper working was still at an experimental stage, in general.

KEYWORDS
Epirus, Rodotopi, hoard, single-edged shaft-hole axes, Early Bronze Age
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Introduction

1. The aim of the present study is to scrutinise a group of twelve cast copper single-edged shaft-hole axes from various sites in Epirus, starting from the hoard of Rodotopi. Typology and distribution in Greece and the Balkans, their manufacturing technology and use-wear are examined, while the results of their metallographic and chemical analysis are discussed. These artefacts are part of the wider context of production and utilitarian (weaponry, tools or units of weight and raw material) or symbolic consumption during the Early Bronze Age in the central Balkans. This early cultural ‘koine’ is characterised by both typological and technological elements, while it traces the networks of raw materials, ideas and commodities, trafficking in the specific areas of the Balkans.

2. The hoard of Rodotopi (Fig. 1) in the region of Ioannina was accidentally discovered in 1951 by an unnamed resident of the area and subsequently handed in to the archaeologist Sotirios Dakaris, without any other information on the exact conditions of its recovery. It includes two intact, as well as two broken, single-edged axes cast with circular shaft-hole. The Rodotopi hoard is today on display in the Bronze Age showcase of the renovated Archaeological Museum of Ioannina, in the first room with various other prehistoric antiquities. There, one can mainly see finds of the Late Bronze Age, as

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The significance of the particular assemblage of this article was first noticed by the author during the works for the re-exhibition of the Ioannina Archaeological Museum permanent collections and subsequently analysed in his doctoral thesis (2013) at the University of Ioannina.

The basin of Ioannina is situated in the heart of the Epirus hinterland at an elevation of about 470–490 m.a.s.l. Its long axis stretches for approximately 38 km in a SE-NW orientation and its width reaches up to about 10 km. The flatland of Rodotopi lies at the northwest end of the Ioannina basin, bordered on the west and the east by hill ranges (from Rodotopi and Megalo Gardiki to Neochori). Up until recently and before it was drained (1958), lake Lapsista occupied part of Ioannina basin immediately north of Rodotopi in communication with lake Pamvotis of Ioannina. A multitude of archaeological sites are dispersed across the wider district of the Ioannina basin, as well as in the environs of Rodotopi, dating from the Palaeolithic period to modern times. Quite important too is the recovery of another three prehistoric metal artefacts in the specific area.

The identification of an Early Bronze Age presence still remains problematic, not only in the basin of Ioannina, but also in Preveza and Katamachi in Ioannina. The hoard was found in 1985 and is assigned to the Late Bronze Age.

Vokotopoulou 1972, 112–119. The hoard was found in 1970 and is also dated to the Late Bronze Age.


Pliakou 2007, 67; 77 f. 91. 97–99. 105 pls. 26. 29. 42. 43. Pottery of prehistoric times is known from the Megalo Gardiki hill and from the Rodotopi area (Vortopos: temple site). It contains sherds of handmade pottery with plastic decoration (K II), with burnished surfaces (K III) and with matt-painted decoration (K IV). In general, the first two categories span the entire spectrum of the Bronze Age, extending also into the Early Iron Age, while the third one dates from the end of the Bronze Age onwards. Furthermore, handmade pottery of prehistoric date from the Rodotopi area was found at the hill of Goritsa within the modern settlement and in the Bisti cave to the NW of the village.

These are a partly preserved and unpublished copper flat chisel (Cat. 13), which was found in 1955 in a field of Rodotopi, a copper single-edged axe (Cat. 5) with circular shaft-hole from Lofiskos (former Tsergiani) to the south of Rodotopi (Hammond 1967, 332 fig. 22 pl. 21), as well as a bronze lanceolate spearhead (AMI 3328) from the hill of Megalo Gardiki to the east (Vokotopoulou 1969, 197 fig. 7 pl. 28). The first two probably date to the Early Bronze Age, while the third one belongs to the end of the Late Bronze Age. They all are random and isolated finds, without any further information on the exact conditions of their recovery.

Fig. 1: The hoard of Rodotopi containing four single-edged shaft-hole axes (Cat. 1–4; scale 1 : 2)
but also in the whole of Epirus, with the exception of three archaeological sites. The first one is Doliana, situated NW of the Ioannina basin in the area of the headwaters of the Kalamas river and the now dried-up Grammoustit lake. There in 1990, the floor of a rectangular hut was excavated: it had two successive phases, yielding hearths, handmade pottery, clay spindle whorls, lithic artefacts, archaeobotanical and bioarchaeological remains. Four radiocarbon dates (3770–2925 cal. B.C.) place it at the end of the Chalcolithic period and the beginning of the Early Bronze Age. The pottery finds parallels in specimens of the Attica-Kephala culture and the Rachmani phase at Pevkakia in Thessaly, but primarily in the Maliq IIb–IIIa phases of neighbouring Albania. The idiosyncratic Chalcolithic phase of the site has been called ›Doliana culture‹.

The second, the site of Goutsoura lies to the SW of Epirus and closer to the sea, in the basin of the Kokytos river headwaters: it was recently excavated by the Finnish Institute of Athens (Thesprotia Expedition). The Goutsoura settlement extends along the ridge of a hill, occupying an area of 0.1 ha. Taking up the baton from Doliana in the chronological sequence, its six radiocarbon dates define a span (2920–2400 cal. B.C.) within phases I–II of the Early Bronze Age. After a hiatus of about 400 years (EBA III), a cremation burial of the beginning of the Middle Bronze Age cuts through the settlement stratum, while at a later stage a burial tumulus (end of the Middle Bronze Age) was erected over it. The settlement stratum contained handmade pottery, among which sherds of ›corded ware‹ stand out, along with clay spoons and spindle whorls, flint artefacts and fauna remains. The pottery finds parallels in Pevkakia, Bosnia, Bulgaria and Romania. Finally, of some interest is a copper punch, a fish-hook and a copper prill, the latter being regarded as a remnant of metalworking activities in the settlement.

7 Papadopoulos 1976, 272: he includes seven sites from Epirus (Aetos, Dodona, Ephyra, Kastritsa, Koutselo, Megali Goritsa, Skala Philiaton) in the Early Bronze Age, remarking on the impossibility of subdivision into phases. Alram-Stern 2004, 751–753: she classifies fifteen sites (adding the sites: Vouvopotamos, Kastritsa, Kasti, Doliana, Palaxiopyrgos, Meropi, Neochori, Pyrgos Ragia) in the Early Bronze Age. The dating of the above sites is mainly based on fragments of handmade pottery with plastic decoration, which is but only slightly differentiated in terms of technology (manufacture, decoration, firing) during the Bronze Age. Dated with certainty to the Early Bronze Age I is the site of Agia Marina at Pedini in Ioannina, which is currently under study by a colleague Vasiliki Siozou (Siozou forthcoming) and from which a radiocarbon date (3330–3030 cal. B.C.) has already been obtained.

8 Douzougli – Zachos 2002, 124–138. 143. The ›Bratislava‹ type of pottery (Maran 1998, 344–346 fig. 1 pls. 1–4) stands out with its spiral decoration, filled with white paste, which is mainly encountered at sites of central Greece, as well as in Albania (Maliq, Tren, Podgorie) and in the Balkans still further north. Coleman 2011, 13. 25–29: The Petromagoula-Doliana group has more in common with EBA I than with the latest Chalcolithic material of the Greek mainland and I argue that it can best be regarded as the earliest manifestation of the EBA (Proto-Bronze Age) on the Greek mainland. Deckwirth 2016, 278 note 73: she makes corrections, regarding the results of the archaeozoological analyses from Doliana (Douzougli – Zachos 2002, 138), after personal communication with P. Halstead [cattle (38.8 %) > sheep and goats (36.1 %) > pigs (12 %), instead of the earlier: sheep and goats (36 %) > pigs (12 %) > cattle (8 %)].

9 Forsén et al. 2011, 79–82 (list of sites); Forsén – Forsén 2012, 297–301 (general description); Forsén 2016a, 125 f. 133–138. 141. 143 (stratigraphy-chronology); Forsén 2016b, 194–200. 204–207 (handmade pottery); Forsén 2011, 65–67 (clay spoons); Doukeridou 2016, 212–217 (flint tools – stone industries); Papayiannis 2016, 227–243 (various small finds); Deckwirth 2016, 261–287 (animal bones: pigs > sheep and goats > cattle).

10 Forsén 2016b, 204–207: for the archaeological sites and the relative bibliography.

11 Papayiannis 2016, 229–231. The three copper or copper alloy objects date also to the Early Bronze Age.
Fig. 2–10: Rodotopi, single-edged shaft-hole axes from the hoard (Cat. 1–4; scale 1 : 3)
A particular group of twelve copper or copper alloy single-edged axes is made up of objects from eight different sites in the wider region of Epirus. These are axes with a circular shaft-hole towards the back and a usually angular or less often rounded butt-end. On the upper side their back is slightly raised in section towards its outside edges, whilst running along its axis, a central line or seam is usually visible, corresponding to the junction of the two stone mould halves, in which these artefacts were probably manufactured. More rarely, a similar line or seam can also be discerned on the lower surface of the axes, where too a large triangular shrinkage cavity is often observed: this is a result of the manufacturing process, discussed further below. As a rule, the blade is larger in its height than the butt-end and preserves quite a few traces of use-wear in most of the examples or has become completely blunted in most of the cases.

An assemblage of four axes (Cat. 1–4: Fig. 1. 2. 3. 4. 5. 6. 7. 8. 9. 10) forms the hoard of Rodotopi in Ioannina, of which one (Cat. 4: Fig. 8. 9. 10) displays six leaf-shaped notches on one side and ten on the other, in a probable attempt to fashion a nigh indiscernible marking (as discussed further below). Yet another axe (Cat. 5: Fig. 11. 12) of the type was found a little further south in the area of Lofiskos (former Tsergiani) in Ioannina. Even further south at Terovo in Ioannina and in the Louros river valley two more artefacts were uncovered. The first one (Cat. 14) is today lost, without any recorded information on its shape and dimensions. The second (Cat. 6: Fig. 13. 14) is fragmented, with a part missing from the rear of the shaft-hole and the butt-end. In a secondary
use, the broken sides of the hole were hammered flat, thus transforming the by then blunted axe into an anvil/wedge (a unique occurrence). Four more axes16 are known from the area of Arta. The first one (Cat. 10; Fig. 15. 16) comes from Pistiana (former Siroupolis) in **Arta**, the second one (Cat. 7; Fig. 17) from Ziros in Philippiada, the third one (Cat. 8; Fig. 18) from the area of Arta in general and the fourth one (Cat. 9; Fig. 19) from Vlaherna in Arta. The twelfth axe (Cat. 11; Fig. 20) of the type was found at Loutro17

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16 Hammond 1967, 332 fig. 22; Konstantaki – Spanodimos 2008, 19. 35. The third one is unpublished, while the fourth one was found by the archaeologist P. Karatzeni at the hill of Agios Nikolaos in Vlaherna in 1994.

17 Hammond 1967, 332 fig. 22. This also is a random and isolated find from Aitolokarnania.
in Amphilochia, just outside Epirus on the east side of the Ambracian gulf. Finally, we should mention two unpublished tools of different types, which in all probability are to be dated somewhere in the Early Bronze Age. These are a cast flat axe/chisel/adze (Cat. 12: Fig. 21. 22) from Anatoli in Ioannina and a copper flat chisel (Cat. 13: Fig. 23. 24) from Rodotopi in Ioannina. Their types are quite common in the Helladic area, the Balkans and Europe throughout Bronze Age.

Earlier researchers\(^8\) in Epirus assigned the chronology of these particular copper single-edged axes to the final phases of the Late Bronze Age. Hammond maintains that the typological group of these axes prevailed in the Laibach culture of Slovenia at the north end of the Adriatic sea. From there, it spread across the Danube river valley, then was adopted by the Urnfield culture in Hungary and expanded eastwards into Bulgaria. The same view is also held by Papadopoulos, who supports a probable local manufacture. At the same time, another group of researchers\(^9\) correctly placed these specific artefacts in the Early Bronze Age, a period that at the time was completely unknown in the region of Epirus. Their early chronology is substantiated by typological and archaeometric data, as it will be seen further below, since they are made from copper-arsenic alloys (Cu-As).

Another fourteen copper or copper alloy single-edged axes of the Early Bronze Age are recorded from the rest of the Helladic region, eleven out of which come from Macedonia. The biggest assemblage of four artefacts is included in the hoard of Petralona\(^20\) in Chalkidiki (also comprising thirty-eight flat chisels). All of the axes are broken at the same point just before the blade (on two the blade is missing, while a third one preserves only the blade). A similar copper axe is reported from the site Latomeia of Triadi\(^21\) in Thessaloniki. There also are three more surface finds: two from the archaeological sites of Mesimeri Toumba and Plagiarou Toumba in the Chalkidiki in Macedonia and a third one, now missing, from Mesimeriani Toumba at Trilofo in the same region. Finally, one axe occurred at each one of the following sites: Mandalo\(^23\) in Pella (excava-
A piece of a sixth stone mould was located in the ›Minoan‹ neighbourhood of the settlement at Koukonisi26 on Lemnos. Finally, part of a single-use clay mould for the manufacture of a single-edged axe occurred at the settlement of Poliochni29 on Lemnos. The latter provides clear evidence for the practice of the ›lost-wax‹ casting technique, being known already in the Early Bronze Age.

Likewise, six pieces of bivalve stone moulds are known in the Helladic area, of which five come from the regions of central and west Macedonia. The first is a surface find from Mesimeri28 Toumba in Chalkidiki, while the second one was found at Agios Mamas28 Toumba in Chalkidiki and is published in an exemplary manner. Two more pieces of stone moulds come from the settlement of Kryopigado at Aliakmonas30 in Kozani and another one from the settlement of Anargyroi31 on the shore of the Cheimaditis lake in Florina. A piece of a sixth stone mould was located in the ›Minoan‹ neighbourhood of the settlement at Koukonisi26 on Lemnos. Finally, part of a single-use clay mould for the manufacture of a single-edged axe occurred at the settlement of Poliochni29 on Lemnos. The latter provides clear evidence for the practice of the ›lost-wax‹ casting technique, being known already in the Early Bronze Age.

Vulpe (1970) has established the principal typological classification of the Balkan copper and bronze single-edged axes with a circular shaft-hole, which remains effective to the present. All Epirotic examples belong to the first variety of the type with the conventional name Veselinovo (after a site in Bulgaria), whose date falls within the Early Bronze Age. Assigned to the same category of axes are three examples, one apiece from Mesimeri Toumba and Plagiar Toumba in Chalkidiki, and Paliouria in Grevena, to go with three stone moulds from Mesimeri Toumba and Agios Mamas Toumba in Chalkidiki and alongside one of the two moulds from Kryopigado at Aliakmonas in Kozani. The second variety of the Veselinovo type is typological and chronological evolution from the first one, including a stone mould from Koukonisi on Lemnos, which should probably be associated with the fourteen axes from the hoard of Ostrovul Corbului24II in Romania. This specific type predominates as the most characteristic group of copper

24 Karamitrou-Mentesidi 2011, 845. This is an important new and basically unpublished find.
25 Maran 1989, 129–136. The hoard was found in 1964 inside a pithos, underneath a floor of an apsidal building and contains six copper/bronze artefacts (double-edged axe, single-edged axe, three chisels and an awl).
26 Bernabò-Brea 1964, 661 f. pl. 173. The hoard was found in room 829 of the red period next to megaron 832, with twenty copper/bronze objects in it (axes, spearheads, daggers, awls, a pin and a small fish-hook).
27 Georgakopoulou 2013, 673–677. The hoard contains three artefacts (single-edged axe, axe-adze and flat chisel). The single-edged axe is made of a copper-tin alloy (Cu-Sn) and preserved in a poor condition (as it was probably an experimental artefact). This site also preserves remarkable traces of metallurgical activities (mainly copper and lead).
28 Grammenos – Tzachili 1994, 90 f. It was found in 1920 in the settlement area.
29 Häsnel 2003, 475–481. On the two main faces are cut depressions for casting a single-edged axe and a triangular dagger, the most characteristic artefact categories of the Early Bronze Age, in general.
30 Karamitrou-Mentesidi – Lokana 2011, 312 f. 320 f. 350. From pits-dwellings 2 and 13a. On the inside of both moulds there are preserved irregular striations in a diagonal arrangement, making a kind of lattice, though they are not decorative. These incisions could be interpreted in two diverse ways: first in the context of the ritual ›killing‹ of artefacts or second as assisting the casting of the metal, by preventing the creation of cracks (they would be then removed from the end product by hammering or even by polishing during the finishing process).
31 Ziota 1996, 548. This is the only mould that preserves metal remains on the inside.
32 Boulotis 2009, 201–206 (mould: 203 f.). Important metallurgical activities were carried out at the site during Koukonisi III phase, which dates to Middle Minoan IIIB – Late Minoan I transitional period. The mould displays six incised lines and two blind holes to help line up the two halves together, while it bears an incised sign-arrow on one narrow side. The occurrence of the mould in late strata can be seen as an intrusive event or interpreted in the context of an unbroken and continuing tradition in metallurgy, something that remains to be proved.
33 Bernabò-Brea 1964, 591 pl. 85; Nalou 1997, 638. From a well next to megaron 605 of Poliochni verde.
34 Vulpe 1970, 35–37, pl. 6. Seventeen occurrences are mentioned in Romania and another eight in Bulgaria.
single-edged axes in the Helladic area, since more than half of the axe and mould occurrences (fourteen out of twenty-six axes and four out of seven moulds) belong to it. Its principal distribution cluster is encountered in the regions a bit further to the north and east in the Balkans (mostly in Romania and Bulgaria).

12 Six copper or copper alloy single-edged axes of the Veselinovo first variety were found at sites in Romania35, along with a piece of a stone mould in the Cernavoda settlement (phase III). Eight more occurrences are known from sites in neighbouring Bulgaria36. Finally, two axes with the traits of the type come from Albania37, an immediate neighbour of Epirus, while a final example is reported from distant Hungary (site Lapujtó). In total, thirty-one single-edged shaft-hole axes and four moulds of the first variety are known from the Balkans.

13 The distinction of artefacts and their classification into types is not always an easy matter. The four single-edged axes from the Petralona hoard in Chalkidiki and a fifth one from Triadi in Thessaloniki belong to Kozarac38 (or Izvoarele) type, as does one stone mould from Kryopigado at Aliakmonas in Kozani and the clay one from Poliochni on Lemnos. The type is quite widespread in Serbia39 and in Bosnia40, where five pieces of clay moulds were also uncovered in two settlements (Debelo brdo and Gradina Almahdže) of the Vučedol culture. A piece of a stone mould comes from the site Pecica in Romania and again of a clay one from Salzburg in Austria, while one specimen occurred at each one of the following sites: Vinkovci in Croatia, Vel’ký Meder in Slovakia and Csáklya in Hungary, raising the number of known moulds of the type to twelve. We complete this survey with the last five Helladic axes (Arhontiko in Giannitsa, Mandalo in Pella, Thebes in Boeotia, Poliochni on Lemnos and Dhaskalio on Keros, along with the last stone mould from the settlement of Anargyroi on lake Cheimaditis in Florina), classified in two relatively close types, bearing Vulpe’s conventional names Patulele41 and Padureni42.

35 Vulpe 1970, 35–37 pls. 5, 65; Ştefan 2007, 83–88. These are the sites: Tulcea (hoard with three examples), Crivit (settlement of Gîna culture), Shițu-Pingâlă (hoard) and an unknown site in Romania.

36 Chernyh 1977, 29–53; Chernyh 1978, 135–152. These are the sites: Veselîno, Gabrovo, Sevlievo, Plovdiv, Bratsigo, Stara Zagora (two) and an unknown site in Bulgaria.

37 Prendi – Bunguri 2008, 241–243 tab. 6. These are isolated finds from the sites Krîmbec-Korçë and Divjak-Lushnë.

38 Vulpe 1970, 39–41 pls. 8, 70. He reports occurrences at sites in Romania, Hungary, Serbia, Slovenia, Slovakia and Moldavia, as well as in the hoard of Kőrüló in Hungary (five) and of Stublo in Ukraine (two).


40 Žeravica 1993, 22–32 pls. 6–8. The study contains thirty-seven axes from Bosnia and Croatia, among which there is a silver axe (with a gold dagger) from the central burial of a tumulus at Mala Gruda in Montenegro: Hansen 2001, 11–59.


42 Vulpe 1970, 42–48 pls. 8–11. He includes seventy axes from thirty sites in Romania.
Table 1: Distribution of Early Bronze Age single-edged shaft-hole axes and moulds in Greece. Types and quantities.

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Fig. 25: Distribution of Early Bronze Age single-edged shaft-hole axes and moulds in Greece. Types and quantities.
In conclusion (Fig. 25, 26, 27), the twenty-six copper or copper alloy single-edged axes and the seven moulds, which come from a total of twenty-three sites in the Helladic area, typologically belong to known and quite widespread Balkan axe types. In terms of quality and quantity, it is possible to pinpoint three core regions, where local manufacture of axes is considered to be quite probable, if not certain. These are the areas of Epirus, central and west Macedonia, as well as the island of Lemnos in the NE Aegean. As we are going to see further below, the hypothesis of local production is supported in the case of Epirus by macroscopic observations on the manufacturing process, as well as by metallographic and chemical analyses.
Manufacturing Technology and Use-Wear Analysis

Traces of the stages in the manufacturing process are often retained in various ways on the surface of metal objects. In this section, we will describe the results of macroscopic observation (with the naked eye). We primarily refer to visible casting defects of artefacts made in stone or clay bivalve or open moulds, since in the Early Bronze Age neither the sand casting technique (moulding boxes or ‘flask’ technique) nor the always rarer metallic moulds had been invented. Undoubtedly, single-edged axes for the most part will have been manufactured in stone bivalve moulds reused many times and less often in single-use clay moulds. Manufacturing defects (shrinkage cavities, gas-holes and dirt inclusions) affect the aesthetic appearance rather than the functionality of artefacts. Most of the above defects are rectifiable after the solidification of the metal and the removal of objects from the mould. Here, the main technique of correction in use was cold hammering (optimal for copper-arsenic alloys), which condenses the mass, rectifies surface defects and forms the final shape and the blades of artefacts. The process is usually completed by polishing the surface of the objects with a grinder or a whetstone. The object is now ready for use or barter.

Most of the single-edged axes from Epirus (except for Cat. 4. 6. 9) display on the lower narrow side right next to the shaft-hole a roughly triangular cavity with an uneven surface, which reproduces in general the outline of the axes. This is interpreted as a shrinkage cavity (Fig. 28) and is an unintended manufacturing feature that does not affect the functionality of axes. It is created during the solidification of metal in the mould, which begins from the thinnest and remotest points, advancing towards the thickest section, where the shaft-hole is. In the process of formation of different metallic structures inside the mould, the most liquid metal moves to fill any voids, as may be produced during the initial solidification at the remotest and thinnest points. This occurrence can be prevented by adding more molten metal and so refilling the mould, an easy procedure, but not applied in our case. Furthermore, the occurrence of the triangular cavity implies that the pouring channel (runner) was placed next to the shaft-hole, at what becomes the underside of the axe, when in use. An important manufacturing defect that tells against the functionality of axes is gas or blow-holes, which leave small polished pits on the surface or worse voids within. The pits are caused by the

![Fig. 28: Shrinkage cavity on lower side of four single-edged shaft-hole axes (Cat. 1. 2. 5. 10)](image_url)
release of gas or moisture, trapped in the mould during the casting; they can be avoided by preheating the mould and attaching a riser tube for letting any gas out (venting). Such pits are observed on three axes (Cat. 1–3: Fig. 29) and a flat chisel (Cat. 13) from Rodotopi in Ioannina. Finally, most of the objects preserve small cavities, indicating dirt inclusions.

17 Almost all of the Early Bronze Age single-edged axes in Epirus bear traces of the joint of the two halves of the stone mould. One axe (Cat. 6) stands out as an exception, because these specific traces have been erased, following the process of a later systematic hammering for its transformation into an anvil/wedge and its second use as such. Traces of such seams appear in the form of a midrib along the raised back of the axes, on the butt’s angular back and as a groove or rib along the lower narrow side. Most of the objects have certainly been hammered after their removal from the mould and then well polished, since only a few small hammering pits can be seen on the surface of just one axe (Cat. 4). Once again, the exception are the hammering pits on the axe (Cat. 6), acquired in the course of its use as an anvil/wedge, for working smaller artefacts on with a hammer.

18 The unique transformation of the single-edged axe (Cat. 6: Fig. 30) from Terovo into an anvil or wedge after the breakage and abandonment of the axe qua axe was achieved in this manner. The edges of the broken shaft-hole were hammered in towards each other, closing the hole and turning the end into an almost square surface, flat to slightly curved. This surface has become exceptionally polished by repeated hammer blows, when it functioned as the anvil’s working surface for shaping other small objects on (a small shrinkage hole is preserved in the middle of it). The distortion now visible on the body and blade of the axe was most probably caused by intensive use. A pair of notches on both the upper and lower narrow sides served to fasten the anvil firmly to its base. Finally, on one face it bears six larger leaf-shaped notches in the middle and three smaller ones on the upper part, in an effort to decorate or personalise it, but this line cannot be pursued any further.
Another exceptional case appears in a single-edged axe (Cat. 4: Fig. 31) from the Rodotopi hoard, which bears six and ten leaf-shaped and wedge-like in section notches on its two sides, respectively. These indentations were executed with a small pointed object, before the metal was completely solidified and when it was still soft, as the metal is marginally lifted by pressure. Subsequently, the object was hammered and polished. In all probability, these particular traces indicate an effort to provide the artefact with a workshop marking and proclaim ownership, unless of course these are unconnected linear components of some decorative theme. In terms of quality, this axe is the best object in the hoard and remains still the only functional one of the four axes. As in the previous case from Terovo, where the craftsman used his imagination, in this one too he might have so marked his pride or ownership (or have been about something else: weight).

The most characteristic use-wear traces and damage on these single-edged axes, as tools for cutting and shaping wood or as offensive weapons (either truly functional or even symbolic items), are encountered on their blades. Three axes are broken (Cat. 2. 3. 6) and almost all (except for Cat. 4) have a blunted blade with shorter or longer indentations and notches on it (Fig. 32), being thereby rendered non-functional. Seven similar wedge-like notches also occur on the back of one axe (Cat. 10: Fig. 32). It is surprising to note the fact that none of the above axes bears any attempt to resharpen their blades, in order to be used again. Furthermore, they had not even been recycled and that too at a period, when people were still experimenting with the «recipes» of copper, in order to obtain the best possible results. The interpretation of a ritual «death» remains open to discussion.
This article now presents the first metallographic analyses to have been carried out on copper or copper alloy artefacts of the Early Bronze Age from Epirus: three single-edged axes (Cat. 2, 3, 6) and a flat chisel (Cat. 13) from Rodotopi and Terovo in Ioannina. Sampling focused mainly on a point on the blade of two axes (Cat. 2, 3:...
Fig. 33. 34), on the anvil’s working surface, formed out of the broken butt-end of the axe (Cat. 6: Fig. 35) and on the chisel’s (Cat. 13: Fig. 36) butt-end. The metallographic samples were examined with an optical metallographic microscope and with a scanning electron microscope (SEM), while their hardness was measured on Vickers (HV) scale. The analyses allow the investigation of the manufacturing process of casting (phases and alloy elements), as well as those following the solidification of the metal and its removal from the mould (annealing, hot or cold hammering). The results are given immediately below.

Bimetallic alloys (copper with low arsenic contents) were recognised throughout. All four samples retain the initial solidification texture, displaying elongated crystals and dendrites. There are also to be observed various smaller inclusions (lead and bismuth) as microsegregations. At the blade edge of the two axes and less along the rest of the portion analysed, a marked distortion and elongation of both the crystals, which have acquired the form of thin fibres, and of the inclusions is evident. A similar distortion occurs not only on the upper working surface of the axe-anvil, due as much to cold hammering after the casting of the tool as to its second use, but also near the outer surface of the sample from the chisel. These particular traces indicate intensive cold hammering after the casting process. Hardness testing determines increasing values from near the butt-end to the blade of the two axes (120–142 and 85–155 HV 0.3/15). The axe-anvil shows an increasing hardness towards the working surface (132–188 HV 0.3/15), as is the case with the chisel too (96–147 HV 0.3/15) towards the outer surface. To summarise, these objects are cast from bimetallic alloys, as it is established by the chemical analyses too. After the solidification of the metal and its removal from the mould, there followed intensive cold hammering to condense the mass and form the final shape and the blade profile of the artefacts. Nevertheless, very small voids were retained in the microstructure as shrinkage cavities. Cold hammering sets some limitations on the
amount of final working of artefacts, since the technique of annealing had not yet been employed in the specific area. The latter is applied mainly to bronze alloys, while it is almost incompatible with the unstable element of arsenic, at least at high temperatures. Only one of the Early Bronze Age single-edged axes (from Dhaskalio on Keros) from the Helladic area was manufactured by a copper-tin alloy.

**Chemical Analysis**

Chemical composition analyses⁴⁴ (Fig. 37. 38) were conducted on four single-edged shaft-hole axes (Cat. 2. 3. 5. 6) and a flat chisel (Cat. 13) from Rodotopi, Lofiskos and Terovo in Ioannina. For the chemical analyses the method of Energy Dispersive X-Ray Fluorescence (EDXRF) was used. The results are of particular interest, as they

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<td>MA–092100</td>
<td>Copper</td>
<td>Flat chisel</td>
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Fig. 35: Micrographs with overview of the hardness test and the microstructure (Cat. 6)

Fig. 36: Micrographs with overview of the hardness test and the microstructure (Cat. 13)

Fig. 37: The identity of the five analysed copper objects from Epirus

⁴⁴ The analyses were performed at the Curt-Engelhorn-Zentrum Archäometrie (CEZA) in Mannheim, which is an Institute of the University of Tübingen in Germany. All of the analyses were funded by the Institute for Aegean Prehistory (INSTAP – USA), to which I extend my warmest thanks for making this interdisciplinary archaeometrical project possible. For the chemical analyses a Quant’X machine of the Thermo-Fischer company was used. See: Lutz – Pernicka 1996, 313–323.
provide us with useful information on the manufacturing technology, on the alloys of copper used and ultimately on the level of technological skills in the area of Epirus, which geographically is away from the large Balkan trade and production centres. After all, there is not any direct metalworking tradition established throughout the Bronze Age, but only quantitative and qualitative data from copper and bronze artefacts.

The chemical composition analyses demonstrate a high content of copper (96–99 %) with small quantities of arsenic (0.76–2.55 %). On the basis of these ratios, it is barely possible to characterise as an alloy the metal, of which the five objects were manufactured, given that one of them contains arsenic under 1 %, which possibly represents a natural component of the metal ore (it occurs in sulphide minerals, such as enargites, tennantites, arsenopyrites) and not necessarily an addition. Notwithstanding their characterisation as alloys or not, their small arsenic content is not sufficient to improve the properties of the pure copper, for which purpose a content higher than around 2 % is required (when worked solely by cold hammering or even with low temperature annealing). This critical level of the arsenic content occurs only in two out of the five artefacts. The optimal level is considered to lie between 3–4 %, with that of around 2–7 % considered broadly suitable. Arsenic has positive effect in the casting as an antioxidant agent, but by being an unstable element, it evaporates easily. It is characteristic mainly of alloys of the third millennium B.C., soon being replaced by tin because of its dangerous toxicity, which can cause poisoning and death to people and animals, as well as environmental contamination for agriculture and animal husbandry.

Older chemical analyses on two copper single-edged axes of the Veselinovo type from Macedonia (Mesimeri Toumba and Plagiari Toumba in Chalkidiki) are similarly characterised by low arsenic contents (1.70 and 0.48 %). A third axe of a different type from Latomeia at Triadi in Thessaloniki seems to have been made of pure copper (As: 0.06 %). Similar analyses were conducted on all three axes of Veselinovo type from the hoard of Tulcea in Romania, demonstrating equally low arsenic contents (0.61–1.75 %), while the same trend is also observed on axes of the type from Bulgaria. Moreover, in the same major research project (SAM), involving chemical analyses, carried out on thousands of objects from the whole of Europe, there were also included four copper single-edged axes of Kozarac type from the Petralona hoard in Chalkidiki. Once more, these are made of alloy with a small amount of arsenic (1.05–1.60 %).

In conclusion (Fig. 39) most of the axes appear to be alloys of copper with small quantities of arsenic (1.05–2.55 %), with but a few artefacts of pure copper (Cat. 5, Plagiari, Triadi and one from Tulcea, with arsenic in the range of 0.06–0.76 %).

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46 Grammenos – Tzachili 1994, 112. In none of the three samples was tin traced.
48 Chernykh 1978, 146 f. These also are artefacts made of pure copper or mainly of a copper-arsenic alloy.
49 Junghans et al. 1968, 262 f. (nos. 9333–9336).
50 Suitable/optimal percentage contents of arsenic occur in artefacts of the Kythnos hoard: Lesley Fitton 1989, 38.
as borderline alloys), whereas very few are made of a developed copper-tin (Dhaskalio on Keros), the occurrence of which signals the arrival of the new technology in the Aegean islands and further eastwards. These islands, due to their central geographical position and the presence of useful ores (Kythnos, Siphnos, Seriphos), chronologically are foremost locally in the taking up of new technological advances. Looking at the Figure 39 that illustrates comparable chemical data for the fifteen single-edged axes, we notice that with regard to nickel (0.02–0.08 %), the two axes of the Rodotopi hoard (Cat. 2. 3: 0.14–0.20 %) stand out slightly and even more so the five axes of Kozarac type from the Petralona hoard and from Triadi in Chalkidiki (0.30–0.46 %). The levels of silver are more stable (0.02–0.09 %), although the two Rodotopi axes again are slightly conspicuous (Cat. 2. 3: 0.12–0.15 %). The content of antimony is between 0.01–0.14 % and that of lead between 0.10–0.99 %. Lead content (up to around 1 %) is considered to be a natural element of the metal ore and not an addition.

**Discussion**

The four copper single-edged axes from the hoard of Rodotopi in Ioannina and the other eight isolated ones from the rest of Epirus are the only metal finds of the Early Bronze Age in the region, with the exception of two copper artefacts from Goutsoura in Thesprotia and two probable ones (Cat. 12. 13) from Anatoli and Rodotopi in Ioannina. There are, it should be remembered, just three excavated archaeological sites (Doliana and Agia Marina in Ioannina, Goutsoura in Thesprotia), which are securely dated with radiocarbon dates to successive phases of the Early Bronze Age (Ι–ΙΙ, while phase III is not yet attested) in the region. The local material culture is characterised by conservative local features (mainly handmade pottery), but also by the first trade contacts with more northern cultures of the Balkans (pottery of ›Bratislava‹ type from Doliana and ›corded ware‹ pottery from Goutsoura). In relation to the copper axes, it seems that the tells and the settlements of central and west Macedonia respectively, stretching between Epirus and the central Balkans to the NE (Bulgaria and Romania), provided a connecting link.
The main hoard of the four copper single-edged axes from Rodotopi in Ioannina is not accompanied by any information on the exact location of its deposition or manner of concealment. It may have been a utilitarian assemblage: the breakage and disuse of three of its axes resulted from their previous intensive use and for their concealment an easily accessible spot was chosen, the ultimate aim being to retrieve them for recycling. On the other hand, it cannot be excluded that they were a votive deposit: here therefore, the breakage and disuse of the three axes would have been part of their ritual ‘death’ (as in the case of Petralona hoard, where patterned breakage of the blades is noticed) and their deposition could have been made in some inaccessible spot with no prospect of retrieval. Indeed, in this part of Ioannina there were in the past areas of stagnant waters (water-land) difficult to access. The neighbouring Lapsista lake only recently became dried-up (1958), as we have already mentioned in the introduction.

The axes of the Rodotopi hoard, as well as the remaining eight artefacts of the type from Epirus, display manufacturing defects (shrinkage cavities and gas or blow-holes). These defaults could have been rather easily prevented (by keeping the mould topped up with liquid metal and by preheating the mould to a suitable temperature). The objects are in fact essentially made of pure copper, as the arsenic content in the alloy is very low and not high enough to improve the properties of the metal. The preoccupation with the typological and manufacturing homogeneity or uniformity of axes in the region implies probable local production or at least an exclusive preference for them in terms of consumption. In any case the craftsmen, who manufactured them, were taking their first steps in the mastering of their craft, still experimenting with the ‘recipes’ and the end-products of their workshops at the onset of the new era (Early Bronze Age).

The overall conservatism of the geographically isolated Epirus is to be juxtaposed against the experimentation, seen in the new copper technology: smiths seized the chance of expressing their imagination and creativity, conveying now indefinable ‘messages’ to the final recipients-users. The copper single-edged axe (Cat. 6), which after its disuse was turned into an anvil/wedge, so acquiring a second ‘life’, is an exceptional case of independent and opportunistic thinking. Equally distinctive is the example of another copper single-edged axe (Cat. 4), on the two faces of which are worked small notched entities with an indefinable meaning. The eight axes of Epirus (omitting those from Rodotopi) are isolated occurrences of artefacts with a utilitarian or/and symbolic character. Quite impressive is the fact that, after the blade of all these axes became blunted, no effort was made to repair the same by hammering and re-sharpening (limitations imposed by the nature of the alloy).

In the rest of the Helladic area, the second core region for copper single-edged axes in Macedonia is of importance, as there is primary evidence for the local production of this type of axes in the region, which thus extends as an intermediate zone between Epirus and the Balkans. The remaining examples (from Lemnos, but mainly from Keros and Thebes) come from hoards and mark the southernmost boundaries for the geographic distribution of the type across the Helladic mainland and the Aegean islands. The functional potentials of copper single-edged axes have been studied in the Balkans with interesting results. The arrival of tin technology already in the third millennium B.C. can improve the properties of the alloy, but the era of single-edged axes was also gradually coming to an end at least for the Helladic area, as the double-edged axes of Minoan-Mycenaean inspiration begin to prevail from the end of that millennium onwards.

The study of the copper single-edged shaft-hole axes of Epirus is not particularly helpful with issues of chronology, as this is established only in a few cases (Manda-
lo, Thebes, Poliochni, Dhaskalio). On the basis of some parallels from the Balkans, they are mainly dated to the phases II–III of the Early Bronze Age, without excluding the possibility of a slightly earlier or even later extension. Even so, we do gain an important insight into the typology and manufacturing technology in the wider context of the Balkan area, which otherwise would not have been brought into consideration. Future excavations or finds are required to further clarify the chronological framework, within which these artefacts were manufactured, used, consumed, deposited or potentially recycled inside the particular cultural horizon of Epirus. Until then, we trust that our study might be of some help to the researchers of Early Bronze Age metallurgy within the wider region of Balkans and Europe.
Catalogue of the Early Bronze Age Copper Artefacts from Epirus

Cat. 1

Copper single-edged shaft-hole axe, AMI 4371 (Fig. 1. 2. 3. 28. 32)
Rodotopi in Ioannina, handed-in hoard (1951).
Length: 17,6 cm; blade height: 7,5 cm; butt height: 6,9 cm; inner diam. of hole: 2,6–3,0 cm; outer diam. of hole: 3,8–4,0 cm; weight: 1243 g.
Cast copper single-edged axe with circular shaft-hole. Intact, with raised back and midrib on it, angular butt at the back, triangular shrinkage cavity and groove left from the mould on the underside. Manufacturing defects due to gas-holes and dirt inclusions, use-wear on the original polished surface.

Cat. 2

Copper single-edged shaft-hole axe, AMI 4372 (Fig. 1. 4. 5. 28. 33)
Rodotopi in Ioannina, handed-in hoard (1951).
Length: 16,7 cm; blade height: 6,5 cm; butt height: 7,0 cm; inner diam. of hole: 2,6–2,9 cm; outer diam. of hole: 3,6–3,8 cm; weight: 1028 g.
Cast copper single-edged axe with circular shaft-hole. Raised back and midrib on it, angular butt at the back, triangular shrinkage cavity and groove left from the mould on the underside. Broke across the middle and joined from two fragments, with chipping along the back in the front half, while the blade is blunted and non-functional. Manufacturing defects due to gas-holes and dirt inclusions, use-wear on the surface. Brown-green oxidation on the original polished surface.

Cat. 3

Copper single-edged shaft-hole axe, AMI 4373 (Fig. 1. 6. 7. 29. 32. 34)
Rodotopi in Ioannina, handed-in hoard (1951).
Length: 17,1 cm; blade height: 7,4 cm; butt height: 5,2 cm; weight: 1096 g; neither inner nor outer diameter of hole is preserved.
Cast copper single-edged axe with circular shaft-hole. Raised back and midrib on it, triangular shrinkage cavity and groove left from the mould on the underside. Broken, rear part of butt missing, with additional crack on the underside of the blade too. Chipping along the back in the front part, while the blade is blunted and non-functional. Manufacturing defects due to gas-holes and dirt inclusions, use-wear on the surface. Brown-green oxidation on the rough surface.

Cat. 4

Copper single-edged shaft-hole axe, AMI 4374 (Fig. 1. 8. 9. 10. 31)
Rodotopi in Ioannina, handed-in hoard (1951).
Length: 18,8 cm; blade height: 5,3 cm; butt height: 7,0 cm; inner diam. of hole: 2,7–3,1 cm; outer diam. of hole: 3,7–4,0 cm; weight: 942 g.
Cast copper single-edged axe with circular shaft-hole. Intact, with raised back and midrib on it, rounded butt at the back, with central rib left from the mould on the underside. Small blade with chipping, probably non-functional. Six small, almost leaf-shaped notches on one side and ten on the other, made by a fine pointed tool after the solidification of the metal, probably to create workshop or private marking on the axe. On the surface quite a few small hammering pits. Brown-black oxidation on the original polished surface.

Cat. 5

Copper single-edged shaft-hole axe, AMI 114 (Fig. 11. 12. 28)
Lofiskos (former Tsergiani) in Ioannina, isolated find from donation.
Length: 18,6 cm; blade height: 7,5 cm; butt height: 6,0 cm; inner diam. of hole: 3,2–3,5 cm; outer diam. of hole: 4,3–4,5 cm; weight: 1451 g.
Cast copper single-edged axe with circular shaft-hole. Intact, with raised back and midrib on it, angular butt at the back, triangular shrinkage cavity and groove left from the mould on the underside. Use-wear of small extent on the surface, chipped, the upper corner of the blunted and non-functional blade missing. Brown-black oxidation on the original polished surface.

Cat. 6

Copper single-edged shaft-hole axe-anvil/wedge, AMI 10966 (Fig. 13. 14. 30. 35)
Length: 14,0 cm; blade height: 7,7 cm; butt height: 5,9 cm; weight: 1214 g; neither inner nor outer diameter of hole is preserved.
Cast copper single-edged axe with slightly raised back at the top. Broken, rear part missing, through which a circular shaft-hole most probably passed. The two parts of the broken butt were hammered forward, creating three cracks in them and making an almost flat or slightly curved surface, thus transforming the unusable axe into an anvil/wedge. This surface has been exceptionally polished by successive hammer blows and bears in the middle a still discernible, but small shrinkage cavity. On the body of the axe a slight distortion can be discerned, caused by prolonged use, while the blade is blunted and non-functional. Wear traces and pits visible on the back, the body and the lower part, some of them caused by the fastening of the anvil to its base, along with a few small dirt inclusions. On one side six bigger leaf-shaped notches in the middle and three smaller ones on the upper part, in an effort to create decoration or marking. Brown-red oxidation with greenish incrustation.
Cat. 7

Copper single-edged shaft-hole axe, AMA 125b (Fig. 17)
Ziros in Philippiada, handed-in isolated find (1953).
Length: 16,6 cm; blade height: 7,0 cm; butt height: 6,7 cm; inner diam. of hole: 2,8–3,1 cm; outer diam. of hole: 3,8 cm; weight: 1090 g.
Cast copper single-edged axe with circular shaft-hole.
Intact, with raised back and midrib on it, angular butt at the back, triangular shrinkage cavity and groove left from the mould on the underside. Small areas of use-wear on the surface and the back, the blade is blunted and non-functional. Brown-black oxidation on the original surface.

Cat. 8

Copper single-edged shaft-hole axe, AMA 125c (Fig. 18)
Arta (unknown provenance), isolated find.
Length: 16,7 cm; blade height: 7,4 cm; butt height: 6,7 cm; inner diam. of hole: 2,8–3,0 cm; outer diam. of hole: 3,8 cm; weight: 974 g.
Cast copper single-edged axe with circular shaft-hole.
Intact, with raised back and midrib on it, angular butt at the back, triangular shrinkage cavity and groove left from the mould on the underside. Several areas of use-wear on the surface and the back, the blade is blunted and non-functional. Brown-green oxidation on the original surface.

Cat. 9

Copper single-edged shaft-hole axe, AMA 6731 (Fig. 19)
Length: 13,8 cm; blade height: 6,5 cm; butt height: 5,9 cm; inner diam. of hole: 2,7–3,1 cm; outer diam. of hole: 4,1 cm; weight: 820 g.
Cast copper single-edged axe with circular shaft-hole.
Intact, with raised back and midrib on it, angular butt at the back. Small areas of use-wear on the surface, the blade is blunted and non-functional. Brown-green oxidation with greenish incrustations on the original surface.

Cat. 10

Copper single-edged shaft-hole axe, AMI 113 (Fig. 15. 16. 28. 32)
Pistiana (former Siroupolis) in Arta, isolated find.
Length: 18,5 cm; blade height: 6,5 cm; butt height: 6,9 cm; inner diam. of hole: 2,8–3,0 cm; outer diam. of hole: 3,9–4,0 cm; weight: 1231 g.
Cast copper single-edged axe with circular shaft-hole.
Intact, with raised back and central midrib on it, angular butt at the back, triangular shrinkage cavity and groove left from the mould on the underside. Horizontal incisions and small areas of use-wear on the surface, the blade is blunted and non-functional. Brown-black oxidation on the original polished surface.

Cat. 11

Copper single-edged shaft-hole axe, AMA 125a (Fig. 20)
Loutro in Amphilochia, handed-in isolated find (1952).
Length: 15,2 cm; blade height: 6,0 cm; butt height: 5,6 cm; inner diam. of hole: 2,4–3,0 cm; outer diam. of hole: 2,8–3,1 cm; weight: 653 g.
Cast copper single-edged axe with circular shaft-hole.
Intact, with raised back and midrib on it, angular butt at the back, triangular shrinkage cavity and groove left from the mould on the underside. Chipping and distortion at two points on the hole and the back, while the blade is blunted and non-functional. Brown-green oxidation on the rough surface.

Cat. 12

Copper/bronze flat chisel/axe/adze, AMI 5893 (Fig. 21. 22)
Anatoli (marshy lake) in Ioannina, handed-in isolated find (1975).
Length: 12,5 cm; blade width: 5,2 cm; butt width: 2,7 cm; blade thickness: 0,2 cm; butt thickness: 0,2 cm; maximum thickness: 1,1 cm; weight: 292 g.
Cast copper/bronze flat and unperforated chisel/axe/adze. Intact, with small areas of use-wear on the surface and the functional blade. Cast in a single-open mould, with surface alterations on one face. Blade plano-convex in section, probable used as adze, while the butt is rounded and wedge-like. Brown-green oxidation on the corroded surface.

Cat. 13

Copper flat chisel, AMI 9875 (Fig. 23. 24. 36)
Preserved length: 13,0 cm; maximum width: 4,3 cm; butt width: 3,3 cm; maximum thickness: 0,5 cm; butt thickness: 0,3 cm; weight: 137 g.

Cat. 14

Copper single-edged shaft-hole axe (today lost)
Terovo in Ioannina, isolated find.
Cast copper single-edged axe with a circular shaft-hole.
Acknowledgements

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