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STUDY OF BRONZE AGE COPPER-BASED SWORDS OF TYPE NAUE II AND SPEARHEADS FROM GREECE AND ALBANIA

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ABSTRACT

Through the present work an effort is made to approach Bronze Age copper-based swords and spears, typologically identical, which have come to light at archeological excavations in Greece and Albania. The main aim of this work is to examine and correlate the copper technology in these areas and this has been attempted for first time. The chemical composition determined gave results on the level of the ancient copper technology, while microscopic examination gave some results on the level of the ancient metalworking (casting and hammering).

The swords of Naue II type (13^{th} -12^{th} century BC) are the last in the series of swords used in Mycenaean Greece. The determination of the chemical composition was done by the use of Atomic Absorption Spectroscopy (AAS), Energy Dispersive X-Ray Fluorescence (EDXRF) and Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) techniques. Also a video microscope was used for the microscopic examination of the objects.

KEYWORDS: Bronze, Swords Naue II, Ancient Metallurgy, AAS, ICP-AES, EDXRF.

INTRODUCTION

The presence of swords of the type Naue II in Greece and Albania, dated in the 12th century BC, that is the end of the Mycenaean civilisation (16th-12th cent.), made them a suitable choice for this research, which is a common enterprise of the two countries.

In Greece these powerful cut and thrust swords are usually found in warrior graves, as grave furnishings that indicate status and social power. There are also present in hoards of bronze objects, hidden at times of uncertainty. They have a strong blade with a broad low midrib and elliptical section. The handgrip and the handguard are flanged. It seems that they were cast in open moulds as those found in Italy (Bianco Peroni 1970). The hilt plates, made of perishable wood or sometimes ivory, had a forked, wishbone shape and they were held in place by rivets on the handgrip and the handguard. The scabbards were made of wood and leather, sometimes decorated with cut out metal pieces and strips (Papazoglou-Manioudaki 1994). The Naue II swords, named after the archaeologist who first studied the type, are classified by I. Kilian (Kilian-Dirlmeier 1993) (fig.1B) and H. Catling (Catling 1961) (fig.1C) according to the typology of the handgrip.

This class of swords, ultimately of western European origin, was introduced into the Aegean, by the Adriatic route, in the second half of the 13th century, prior to the collapse of the Mycenaean palatial society. The earliest examples come from Mycenae and the island of Kos in the Dodecanese. During the course of the 12th century the swords of type II, of local manufacture, were widely distributed in the Greek mainland and the islands (fig.1A), especially in Achaea and Arcadia in the Western Peloponnese (Papazoglou-Manioudaki 1994; Papadopoulos 1999) and also on the islands of Naxos, Crete and Cyprus. The circumstances, after the fall of the Mycenaean palaces, favoured now the growth of local centres and witnessed the rise of a new class of warriors at a rather disturbed time. These warriors were equipped with type II swords that became predominant over the contemporary Mycenaean type F and G swords, which had thinner and usually shorter blades. Bronze spearheads and pair of graves were also part of the warrior's armoury (Papazoglou-Manioudaki 1994). In the Early Iron Age type II swords are the only chosen to be made into iron. Bronze swords of the same type were still in use as in the case of the Iron Age tumulus cemetery at Vergina in Macedonia (Kilian-Dirlmeier 1993).

There is evidence for contacts between Mycenaean Greece and the southwest region of Albania from early on. The rich graves of Pazhok (Prendi 2002), dated in the 15th century, are furnished with a long type A

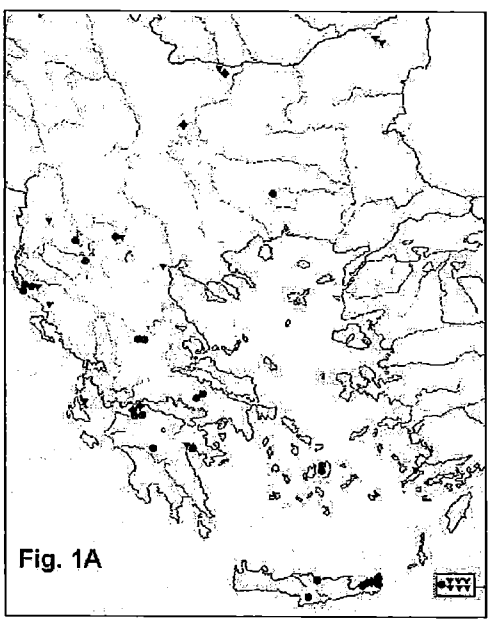

Fig. 1: (1A) Distribution chart of swords of type Naue II in Greece and Albania.

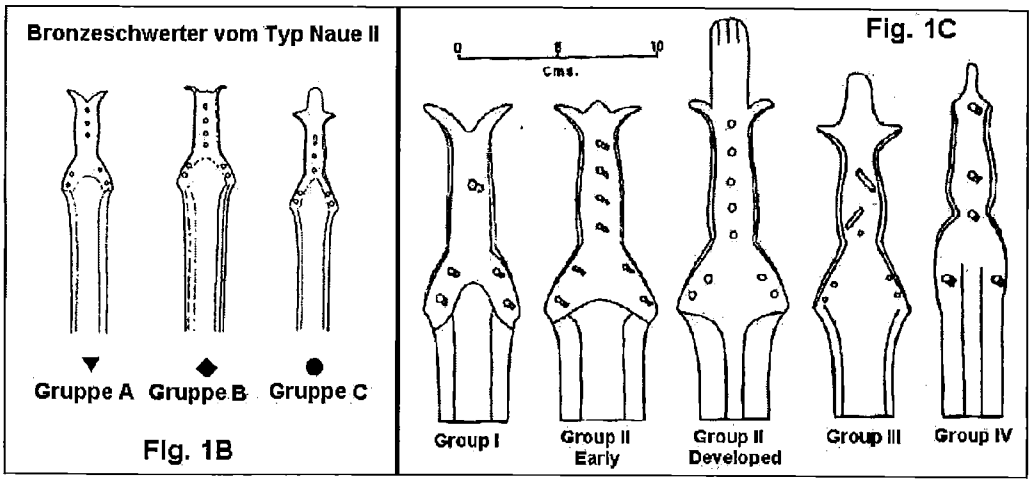

Fig. 1: (1B) Classification of swords of type Naue II according to Kilian, (1C). Classification according to Catling

sword, similar to the ones from the royal graves at Mycenae and a clay Vapheio-type cup with painted decoration. In the 12th century BC, warrior graves in the extensive tumulus cemeteries in the same area were furnished with Naue II swords and spearheads. The Type II swords were found at Barc and Prodan (Kolonje) in the region of Korce (Koritsa) (Aliu 2002), Pazhok in central Albania, Kakavia, Dukat and Vajze (Vlore) towards the Adriatic Sea (Kilian-Dirlmeier 1993; Bodinaku 1990). It is interesting that some swords of both regions appear to have similar characteristic traits, as the pommel spur, with the Italian Naue II swords of the Allerona type (Papazoglou-Manioudaki 1994; Bodinaku 1990). Mycenaean pottery, dated in the 12th century and related to Achaea, is also found at Barc and other sites (Prendi 2002; Touchais 2002). The tombs at the region Korce provided also a number of spearheads, leaf shaped or flame shaped (Aliu 2002), of types known also in western Greece, Epirus and Achaea in the Peloponnese (Papadopoulos 1999; Avila 1983).

MATERIALS

The focus of the present research are the Naue II swords, a type known from Greece and Albania in the same period, that is the 12th century BC, the final age of the Mycenaean civilisation. Spearheads from both regions were also examined. The examination included the analysis of their chemical compositions and the study of their manufacturing techniques. New information on the technology of these weapons and on the possible contacts between the two regions was the aim of the research.

The Greek party provided a total of ten (10) objects, nine (9) Naue II swords and one (1) spearhead, that all belong to the Prehistoric Collection of the National Archaeological Museum at Athens (fig.2). They come from Mycenae (1017, 2539, 2740), Tiryns (6228a, 6228b), Euboea (15176/16591), Patras (10185, 10186) and two are of unknown origin (9885, 13905). The swords from Tiryns and one from Mycenae belong to hoards while inv. no 1017 was found in the House of the Warrior's Vase and inv. no 2740 in the area

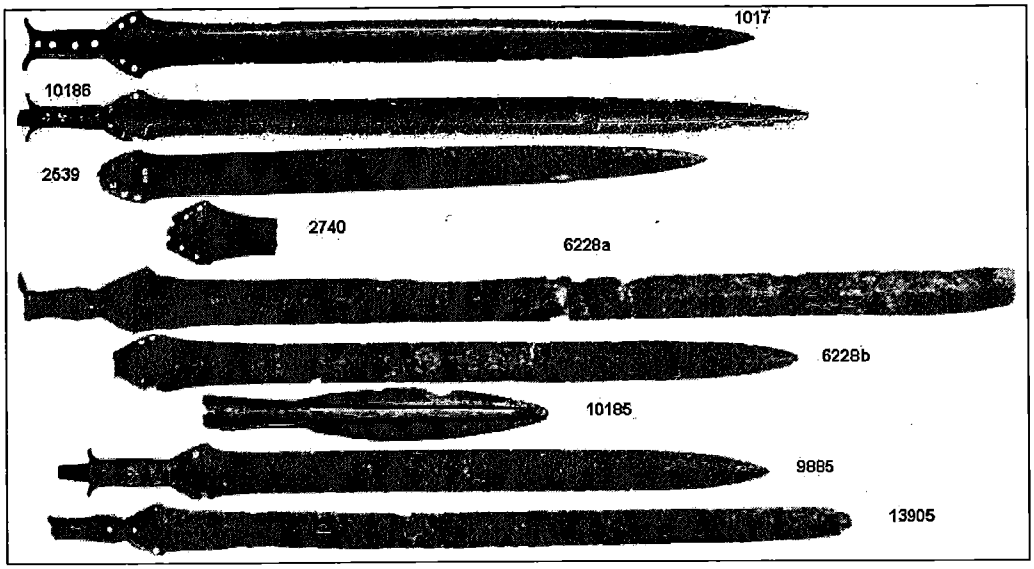

Fig. 2: Copper-based swords of type Naue II and spearheads from the Prehistoric collection of the National Archaeological Museum of Athens.

of the Cult Centre at Mycenae. The sword and the spearhead from Patras come from a tomb near the wine factory of Achaia Klauss while the sword from Euboea from a tomb in the region of Ag. Georgios, Avlonari (Kokkevi-Fotiou 2004). The sword no 1017 is classified to group I (Catling) or group A (Kilian) while nos 10186 from Patras and 9885 belong to group II developed (Catling) or group C (Kilian). The handgrip of most swords is not in a good state of preservation and therefore is not easy to specifically classify them.

The Albanian party provided nine (9) specimens, six (6) Naue II swords (fig.3) and three (3) spearheads (fig.4) that come from the excavations at Korce (nr 1 S. Aliu), Rehovas (178), Luaras (141/224, 140/273), Rashtan (16001), Barc (8488), Pazhok (2268, 1047) and Mavrone (1049). They belong to the collections of the Korce and Erseka Archaeological Museums, the Archaeological Museum of Tirana and the Historical Museum of Tirana.

A few comments can be made on the classification of the swords and their correlation with those from Greece. The swords from Barc no 8488 and Mavrone no 1049 have the characteristic handgrip of swords belonging to group I (Catling) or group A (Kilian) as the sword no 1017 from Mycenae. The sword no 1047 from Pazhok may be classified to group II (Catling) or group C (Kilian) as the sword no 10186 from Patras. On the similar swords from Pazhok no 2268 and Euboea no 15176 there is an obvious repair in the area of the handguard. Finally it is worthy to note that the Nr. 1 sword from Korce seems typologically close to group B (Kilian), which is not common in Greece.

ANALYTICAL METHODS

A. Greek samples

In order to be determined the chemical composition of the Greek weapons, a sample of 50 mg weight, in filings form was necessary. The sample was taken from each object by a stainless steel drill of 2mm

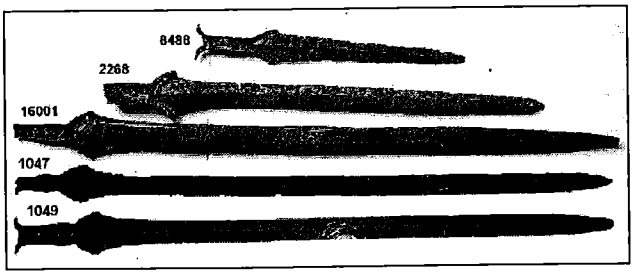

Fig. 3: Copper-based swords of type Naue II from collections of Albanian Museums.

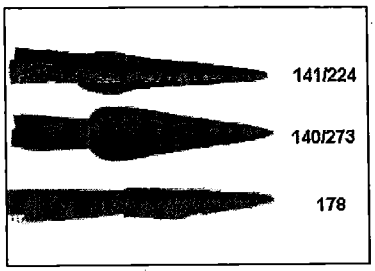

Fig. 4: Copper-based spearheads from collections of Albanian Museums.

diameter, from points that didn't harm the aesthetic of the objects. The samples were dissolved in aqua regia and diluted with HCl 10% (v/v). The elements Cu, Sn, Zn, Pb, As, Sb, Fe, Ni, Co, Bi, Au and Ag were determined by Atomic Absorption Spectroscopy (AAS) (Koui *et al.* 2004). Especially the elements As and Sb were determined by a Perkin-Elmer spectrometer (model 5000) with graphite furnace (HGA 500) while the rest were determined by a Perkin-Elmer spectrometer (model 375) with a flame of acetylene-air or of N_2O-air. The AAS analyses were done in the Chemical and Physical Research Department of the National Archaeological Museum of Athens. The trace elements Bi and Au were also determined by the Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP-AES) in a JY 138 Ultrace Jobin Yvon spectrometer of the Chemical Engineering School, NTUA.

The samples used for the AAS measurements, were also used for the measurements by the ICP-AES.

The spectroscopic lines used for the ICP-AES measurements are 242.795 nm for the Au and 223.061 nm for the Bi respectively while the detection limit is 0.01μg/ml or 0.002% w/w. and the standard deviation is 0.001μg/ml or 0.0002% w/w.

Finally for the microscopic examination of the objects a video microscope of Keyence (model VH-5911) was used.

B. Albanian samples

The determination of the chemical composition of the Albanian samples was done by AAS and EDXRF (Energy Dispersive X-Ray Fluorescence Spectrometry) methods. For the (AAS) analyses the same methodology as for the Greek samples was applied and the measurements took place in the Laboratory of the National Archaeological Museum of Athens.

For the EDXRF analyses the measurements were done by the portable instrument of the Tirana University in the Archaeological Museum of Tirana, without taking off the corrosion layers in the measuring points. The EDXRF instrument consisted of an Am-241 radioactive source and a Si-PIN detector determining the elements from K (19) to Br (35) with K line and from Ag (47) to La (57) with L lines. Although the objects have been conserved, their surfaces were heterogeneous because of different corrosion rates.

DISCUSSION - RESULTS

The chemical analyses by AAS (Tables 1 and 2) showed that all the examined objects are made from bronze with tin (Sn) contents ranging from 4.59 % to 12.88 %. Most of the objects are from bronze with high tin contents (>7%). These bronze alloys have better mechanical properties (hardness and resistance) and are adjusted to the functionality of the objects. However two of

the Albanian objects (a sword Nr.1 Aliu and a spear no.141/224) present lower tin contents (5.58 and 4.59 % respectively).

The determined elements Au and Bi were not detected by the AAS measurements because the detection limits of the method for these elements are 0.02μg/ml. The ICP-AES method applied for these elements showed that from the Creek samples only the objects No 1017 and No 2539 contain Bi 0.03 % w/w and 0.012 % w/w respectively (Table 3).

The rest of the determined elements (Zn, Pb, As, Sb, Fe, Ni, Co and Ag) are present in low percentages, mainly < 1% and in certain cases < 0.1% (level of trace element). That shows the possibility of producing a good quality bronze. The above low percentages are justified as admixtures to the initial copper minerals or probably to the use of scrap copper. All objects are characterized by copper with As and Sb presence.

The presence of the secondary elements As and Sb and the trace elements Bi, Ni, Co, Sb, Ag, Au in the Greek swords strengthen the opinion that the Aegean area could be a possible source of copper minerals. The multimetallic metalliferous Aegean area in Cu-As and in certain cases in Cu-Sn (Skarpelis 2003) with the presence of the elements as Bi, Ni, Co, Sb, Ag and Au has been recorded by the Institute of Geological and Mineral Research (IGME) (IGME 1973) and has been correlated to chemical compositions of prehistoric copper objects (Skarpelis 2003). The same general remarks are related to the composition of the Albanian samples, which present a high average percentage of Sb. However it is difficult to assume the possible source of origin of the copper mineral, since there are no specific geological data for Albania. However the analytical results from a large number of copper objects, mainly of European origin of the Early Copper Age (Junghans 1968) have shown that their copper contains elements as Ag, Ni, As, Sb and Bi. It is known that such copper minerals have been located in the wider Balkan area, in Caucasus, and in the central Europe, Germany, Austria, Hungary, etc (Coghlan 1975).

The comparison of the chemical composition of swords per pairs of the same typologically subclasses give the following results:

1. The swords no. 1017 and no. 8488, of subclass A according to Kilian, and subclass I according to Catling, have roughly the same composition. Special importance should be given to the Sb percentage, which is for both swords 1.22% and 1.8% respectively. This value differentiates the Greek sword no. 1017 from the other Greek weapons that present a low Sb content (the second highest value is 0.27%). On the other hand the Albanian weapons present >1% Sb. The differences of all other determined elements are too small, which could show a potential use of a same composition copper mineral or of a same workshop.

2. The swords no. 10186 and no. 1047, of subclass C according to Kilian, and subclass II according to Catling, have a resembling composition with regard to the main elements Cu and Sn, but differences with regard to the rest elements. Moreover the Greek sword no.10186 contains 0.77% Zn, where the second highest value of the rest Greek weapons is 10 times less. It also contains the highest percentages, compared to other Greek weapons, of Pb (0.68%) and As (0.64%). However these values are not much higher above the respective average ones. This fact differentiates this sword from the rest ones and could be an indication of different origin copper mineral or workshop. The percentages of Zn, Pb and As

of the Albanian sword no.1047 are 0.07 %, 0.16 % and 0.06% respectively. This sword contains also a higher percentage of Sb (0.87%) in comparison to the sword no. 10186 (0.12%).

3. Bigger differences are noticed between the swords no. 15176 and no. 2268, where there is no accordance even for the main alloy elements. Sword no.2268 has 3% more Cu (90.39% and 87.25% respectively) and 4.7% less Sn (12.07% and 7.35% respectively). Big variation is noticed also at Sb (1.58% and 0.18% respectively) and smaller at Ni (0.39% and 0.04% respectively). From the comparison of the two last cases results a potential use of different mineral or workshop.

Other weapons that differentiate a bit from the average are:

The Albanian sword no.1049 contains 1.33% As, while the rest Albanian weapons contain max. 0.08%. On average, Albanian weapons contain lower As percentages compared to the Greek ones.

The Albanian sword no Nr.1 S. Aliu contains a high percentage of Sb (2.99%). There are also 3 more Albanian weapons with high values of this element: no.2268 (1.58%) and the pre-mentioned no.8488 (1.8%) and no.1047 (0.87%). These values increase a lot the average Sb percentage for the Albanian weapons, while the Greek one no.1017 is the only one with Sb percentage (1.22%).

All the above variations don't spoil the general conclusion, that there are not extreme variations in the percentage of the secondary elements of both Greek and Albanian weapons.

For the Albanian samples apart from the AAS measurements EDXRF measurements were also made and the results are appeared in Table 4.

Both methods were pre-checked by the same British chemical standards (No 207/2 gunmetal, No 364 leaded bronze and the BCS-CRM No183/4 leaded gunmetal of the Bureau of Analyzed Samples Ltd.

In Table 5 is reported a comparison between AAS measurements (Table 2) and EDXRF (Table 4). For the same samples are noticed big differences due to the different accuracies of the two analytical methods. Also the EDXRF analysis is a superficial technique and consequently more prone to errors due to the different corrosion states in the measuring parts. The AAS method is a bulk analysis with better accuracy ± 2%. That's why there is a so large difference up to 200% in standard deviation. For the secondary elements the higher values, present higher standard deviations. But even for the main elements (Cu, Sn) the measured values between these two techniques differ a lot. For these reasons the AAS measurements are considered more reliable.

The metallographic examination of the weapons for a scientific documentation of their manufacturing technique (casting or hammering) wasn't possible. The necessary sample, for this examination in form of a piece, taken off the objects, unfortunately, wasn't affordable.

The macroscopic as well as the microscopic examination of the pointed edge of some of the objects (for example no.6228a) (fig.5) can assure an initial casting in two open mirror moulds and a consequent welding by hammering of the two parts together. A possible hammering of the edges could improve the utilitarian properties of the objects as weapons. The unique open stone mould of casting sword of type Naue II, that was found in Italy (Bianco Peroni 1970) can enhance these microscopic observations.

In fig. 6, are distinguished the final polishing lines across the sword stem. In fig. 7 are noticeable the apertures of fixing the

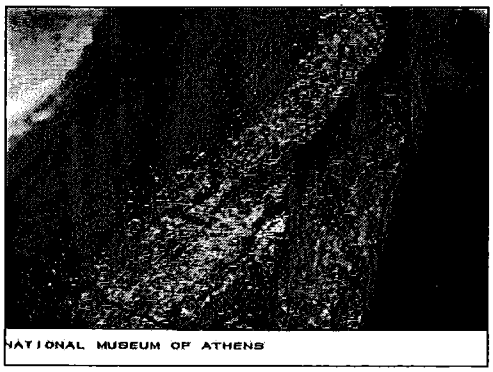

Fig. 5: Sample 6228a. Pointed edge of the sword.

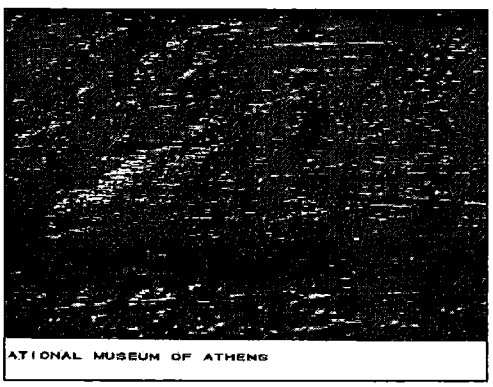

Fig. 6: Sample 1017. Polishing lines across the sword stem (near the pointed edge).

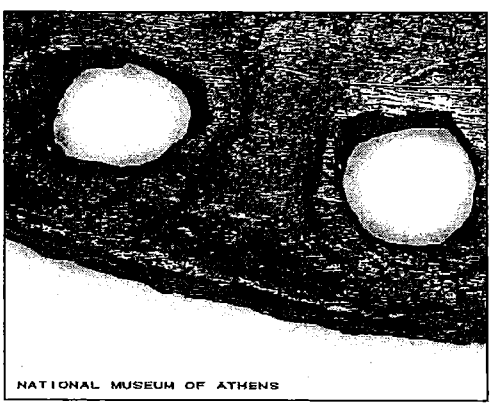

Fig. 7: Sample 1017. Two same apertures and the respective folded finishing.

handles of the swords. Around these apertures are noticed folded finishings of the bronze used that can assure that these apertures were opened after the initial casting of the sword.

CONCLUSIONS

In this study were examined copper-based weapons from Greek and Albanian area. Most of them were swords of type Naue II typologically identical as well as some spears.

The AAS analyses showed that they were made from bronze with percentages of Sn 4.59%-12.88%. The remaining elements are admixtures originating either from the initial copper mineral or from the use of useless (scrap) copper objects of earlier periods that are characterized by the presence of arsenic (As).

From the comparison of the composition of the swords per pairs of same typological subclasses, results that only the swords of subclass A according to Kilian and subclass I according to Catling have an almost identical composition. This leads to the conclusion of a possible origin from a same workshop. This does not appear to be in effect for the two other pairs of swords.

The AAS method is the more reliable method of elemental analysis instead of the EDXRF, where the measurements were made superficially and on corroded surfaces. The examined weapons could possibly originate, from copper minerals of the Aegean or Balkan area, where exist relatively high percentages of As, Sb as well as of some of the rest trace elements determined (Bi, Ni, Co, Ag, Au).

The microscopic examination could show that the swords of type Naue II were made by initial casting of two individual parts across the sword, in separate open moulds, and afterwards welding with hammering.

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REFERENCES

Aliu, S. (2002) Les rapports entre l'Albanie du Sud-est et l' Europe centrale pendant la transition de l' age du Bronze al' age de fer, a la lumière des découvertes de Kolonje, L'Albanie dans L'Europe Préhistorique. In: *BCH Suppl. 42*, 217-229.

Avila, R. (1983) *Bronzene Lanzen-und Pfeilspitzen der griechischen Spätbronzezeit*, Prähistorische Bronzefunde IV, 1.

Bianco Peroni, V.(1970) *Die Schwerter in Italien*, Prähistorische Bronzefunde IV, 1.

Bodinaku, N. (1990) Poignards de Bronze provenant de l'Albanie du Sud. In: *Iliria*, 85-97 (in Albanian with summary in French).

Catling, H. (1961) A new bronze sword from Cyprus. In: *Antiquity*, vol. 35, 115-122.

Coghlan, H. H. (1975) Notes on the Prehistoric Metallurgy of Copper and Bronze in the Old World. In: T.K. Penniman and B. M. Blackwood (eds.), *Occasional Paper on Technology 4*, 2nd ed., Oxford.

Institute of Geological and Mineral Research (IGME) (1973), *Explanatory edition of the Metal map of Greece*, Athens.

Junghans, S., Sangmeister, E. and Schroeder, M. (1968) *Kupfer und Bronze in der frühen Metalzeit Europas*, Band 1-3, Berlin.

Kilian-Dirlmeier, I. (1993) *Die Schwerter in Griechenland (außerhalb der Peloponnes), Bulgarien und Albanien*, Prähistorische Bronzefunde IV, 12.

Kokkevi- Fotiou, D. (2004) *Bronze votive coach from the Mycenaean grave at Saint George-Avlonari Euboea, Proceedings of the International Archaeological Conference "Euboea in antiquity, aspects of public and private life" Chalkis* (in Press) and "Bronze sword type Naue II from Mycenaean grave at Saint George-Avlonari Euboea", under study.

Koui, M., Andreopoulou-Mangou, E., Papazoglou-Manioudaki, E. and Papandreopoulos, P. (2004) Preliminary results from the study of the composition and the Manufacturing technique of Prehistoric Age copper objects from the Greek area (in Greek), Proceedings of the 2nd Greek Congress of Metal Materials, NTUA, Athens, 143-150.

Papadopoulos, T. (1999) Warrior graves in Achaean Mycenaean cemeteries, In: *Aegaeum*, vol. 19, 267-274.

Papazoglou-Manioudaki, L. (1994) A Mycenaean warrior's tomb at Krini near Patras. In: *BSA*, vol. 89, 171-200.

Prendi, F. (2002) Les relations entre l'Albanie et l'Egée à travers la Préhistoire, L'Albanie dans L'Europe Préhistorique. In: *BCH, Suppl.42*, 85-96.

Touchais, G. (2002) Les rapports entre le monde Mycénien et ses marges Nord-Ouest (Epire, Albanie, Macédoine), L'Albanie dans L'Europe Préhistorique. In: *BCH Suppl. 42*,199-215.

Skarpelis, N. (2003) Ancient Potential tin sources in the Aegean. In: Alessandra Giumlia - Mair and Fulvia Lo Sciavo, 'The problem of Early tin', Acts of the XIVth UISPP Congress, Univ. of Liege, Belgium, 2-8 Sept. 2001, BAR International Series 1199, 159-163.

Table 1: % Chemical Composition determined by AAS of type Naue II Copper Swords of the National Archaeological Museum of Athens, Late Bronze Age (12th century BC)

Object No	Description	Origin	Cu	Sn	Zn	Pb	As	Sb	Fe	Ni	Co	Ag	Bi*	Au*
1017	60,1 cm length entire	Mycenae	89.4	8.28	0.07	0.54	0.13	1.22	0.1	0.1	0.06	0.1	n.d	n.d
2539	50,8 cm length. Defective at the handhold	Mycenae	87.16	11.6	0.05	0.53	0.06	0.27	0.2	0.04	0.04	0.1	n.d	n.d
2740	8,6 cm length. Part of the blade and the convex shoulder	Mycenae	92.68	5.94	0.01	0.29	0.56	0.16	0.2	0.08	0.04	0.02	n.d	n.d
16591 (15176)	40 cm length Insufficient in the handhold	Euboea	87.25	12.07	0.01	0.25	0.11	0.18	0.1	0.04	n.d	0.01	n.d	n.d
6228a	81 cm length defective at the handhold and at the sharp edge	Tiryntha	86.76	12.88	0.02	0.02	0.06	0.05	0.1	0.04	0.04	0.04	n.d	n.d
6228b	55,1 cm length. Defective at the handhold	Tiryntha	91.18	8.3	0.01	0.18	0.08	0.06	0.1	0.05	0.03	0.01	n.d	n.d
10185	27 cm length Spear	Antheia (Klauss) Achaia	89.79	9.12	0.06	0.23	0.2	0.15	0.3	0.04	0.09	0.01	n.d	n.d
10186	65,5 cm length entire	Antheia (Klauss) Achaia	86.79	10.91	0.77	0.68	0.64	0.12	0.1	0.06	0.04	0.02	n.d	n.d
9885	57,7 cm length entire	Of Unknown Origin	90	9.01	0.01	0.05	0.37	0.07	0.2	0.05	0.1	0.1	n.d	n.d
13905	66,8 cm length. Defective at the little tongue at the edge of the handhold	Of Unknown Origin	88.81	10.08	0.01	0.31	0.25	0.17	0.2	0.07	0.04	0.1	n.d	n.d

*n.d. =not detected <0.02μg/ml. The elements Bi and Au t were also determined by the ICP-AES technique

Table 2: % Chemical Composition determined by AAS of Copper Weapons from Albania, Late Bronze Age (12th -10th century BC)

Object No	Description	Origin	Cu	Sn	Zn	Pb	As	Sb	Fe	Ni	Co	Ag	Bi	Au
	Korce Archeological Museum													
Nr.1 S.Aliu	Naue II type Sword	Korce	89.94	5.58	0.02	0.7	0.1	2.99	0.28	0,19	0.03	0.17	n.d.	n.d.
	Ersheka Archeological Museum													
178	Spear	Rehova 1980, Grave 178	91.3	8.46	n.d.	n.d.	0.05	0.02	0.12	0.04	n.d.	0.004	n.d.	n.d.
141/224	Spear	Luaras 1989,Grave 60	94.66	4.59	n.d.	0.16	0.06	0.04	0.47	0.02	n.d.	0.003	n.d.	n.d.
140/273	Spear	Luaras 1988,Grave 7	90.82	8.9	n.d.	n.d.	0.08	0.05	0.09	0.05	n.d.	0.007	n.d.	n.d.
	Archeological Museum Of Tirana													
16001	Naue II type Sword	Rashtan (Librazhd)	87.58	12.09	0.007	0.06	0.01	0.03	0.17	0.03	n.d.	0.02	n.d.	n.d.
8488	Naue II type Sword	Barc (Korce)	88.89	8.47	0.03	0.35	0.06	1.8	0.12	0.17	0.02	0.09	n.d.	n.d.
2268	Naue II type Sword	Pazhok (Elbasan)	90.39	7.35	0.009	0.08	0.05	1.58	0.09	0.39	0.02	0.04	n.d.	n.d.
	Historical Museum Of Tirana													
1047	Naue II type Sword	Pazhok (Elbasan)	85.87	12.59	0.07	0.16	0.06	0.87	0.18	0.18	0.04	0.11	n.d.	n.d.
1049	Naue II type Sword	Mavrone (Valone)	85.77	11.53	0.15	0.05	1.33	0.22	0.42	0.06	0.01	0.37	n.d.	n.d.

AAS=Atomic Absorption Spectroscopy, n.d. =not detected. The percentage of copper was determined by the % difference of the rest elements.

Table 3:
% Chemical Composition determined by ICP-AES of the type Naue II Swords of the National Archaeological Museum of Athens

Object No	Bi	Au
1017	0.03	n.d
2539	0.012	n.d
2740	n.d	n.d
16591 (15176)	n.d	n.d
6228a	n.d	n.d
6228b	n.d	n.d
10185	n.d	n.d
10186	n.d	n.d
9885	n.d	n.d
13905	n.d	n.d

nd=not detected <0.01μg/ml

Table 4: EDXRF Measurements of the Albanian type Naue II Swords

Element	No 8488 N=8		No 2268 N=5		No 16001 N=5		No 1047 N=5		No 1049 N=3	
	A.M.	% STD	A.M.	% STD	A.M.	% STD	A.M.	% STD	A.M.	% STD
Cu	81	1.8	78.5	0.9	66.9	4.8	75.6	10.5	84.7	5.5
Sn	17.5	7.9	20	5	32.8	10.1	23.1	33.2	13.5	31.4
Zn	0.5	71.1	0.3	37.4	0.04	38	0.8	42.5	0.4	53.5
Fe			0.7	44.1	0.1	143.8	0.1	200	0.6	61.2
As	0.5	10.5	0.2	33.5	0.06	149.1	0.2	30.7	0.7	7.9
P	0.5	23	0.3	21.2	0.1	66.4	0.3	31.7	0.1	24.9

Table 5: Comparison between EDXRF - AAS measurements of the Albanian type Naue II Swords

Sample	No 8488			No 2268			No 1047			No 1049			No 16001		
Method	EDXRF		AAS	EDXRF		AAS	EDXRF		AAS	EDXRF		AAS	EDXRF		AAS
Element	A.M.	%STD		A.M.	%STD		A.M.	%STD		A.M.	%STD		A.M	%STD	
Cu	81	1.8	88,89	78.5	0.9	90,39	75.6	10.5	85,87	84.7	5.5	85.77	66.9	4.8	87.58
Sn	17.5	7.9	8,47	20	5	7,35	23.1	33.2	12,59	13.5	31.4	11.53	32.8	10.1	12.09
Zn	0.5	71.1	0,03	0.3	37.4	0,009	0.8	42.5	0,07	0.4	53.5	0.15	0.04	38	0.007
Fe	-	-	0,12	0.7	44.1	0,09	0.1	200	0,18	0.6	61.2	0.42	0.1	143.8	0.17
As	0.5	10.5	0.06	0.2	33.5	0,05	0.2	30.7	0,06	0.7	7.9	1.33	0.06	149.1	0.01

N =Number of measurements, A.M. =Average Measurement, %STD =% Standard Deviation