

TECHNOLOGIES OF WARFARE. THE XRF ANALYSIS OF ARROWHEADS FOUND IN THE SCYTHIAN NECROPOLIS FROM CELIC-DERE (ROMANIA)

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An interdisciplinary approach to studying the alloy composition of warfare Scythian-type arrowheads found in the graves excavated during older archaeological research in the necropolis from Celic-Dere, Tulcea County, Romania was applied. Based on the characteristics of the funerary structures, which were present as burial mounds covering inhumation graves, and the typology of the grave goods, the necropolis was identified as belonging to a Scythian community, living in the area from the end of the 7th century BC until the beginning of the 5th century BC. From the large number of arrowheads, which could be accessed at present in the collections of the Institute for Eco-Museum Research Tulcea, 78 items were selected during this phase of research, taking into consideration their association in graves and their typological details.

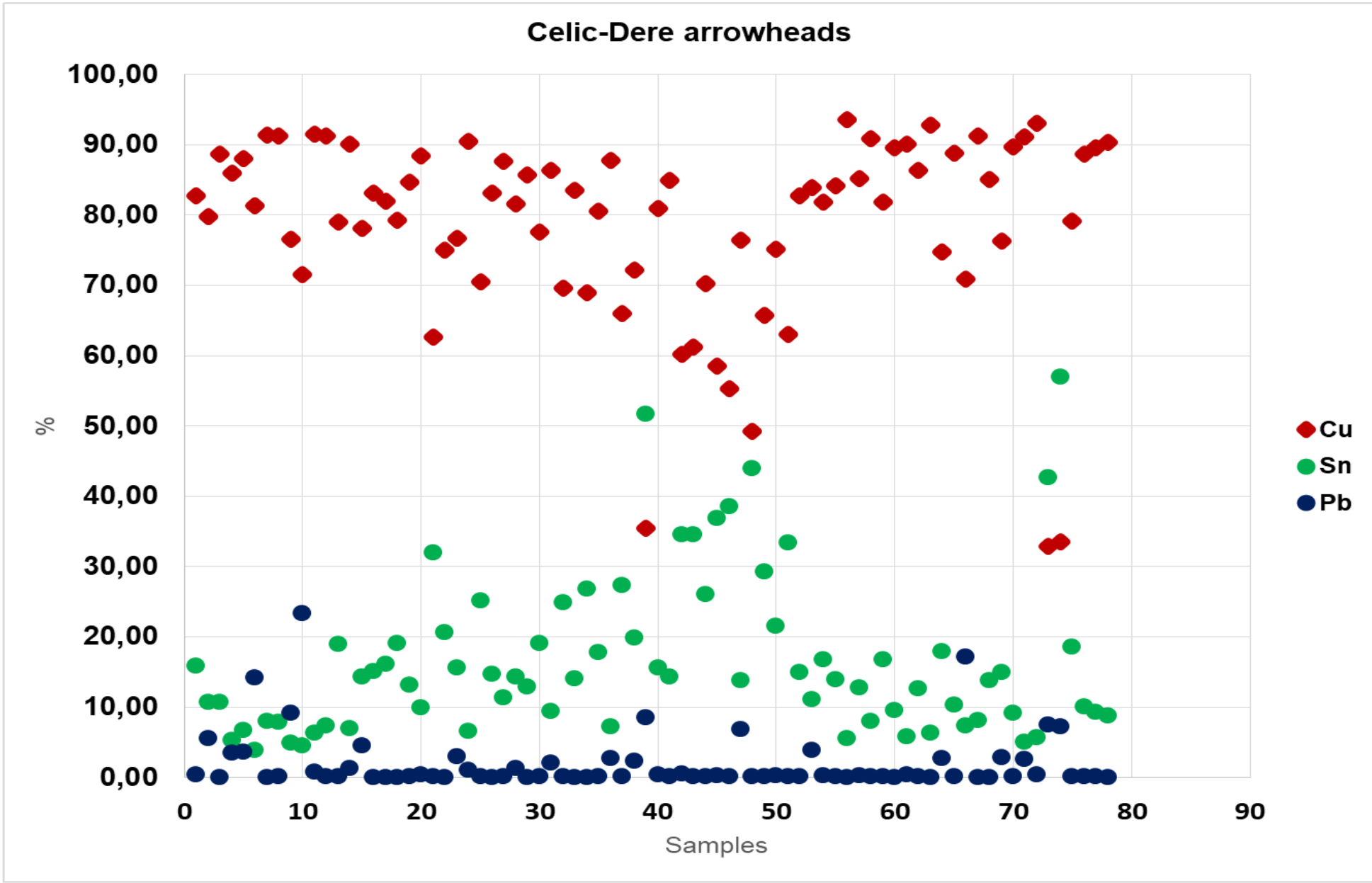
The composition of the 78 Scythian-type arrowheads was analyzed using X-Ray Fluorescence method (XRF), which indicates the general elemental composition (investigated area - approx. 10 mm²) in order to identify technological production processes and to identify some clues regarding the origin of the constituent metal (from the perspective of metal ores and geological deposits). It should be mentioned that the arrowheads still preserve their patina, which could not be removed for the purposes of compositional analysis, situation influencing the percentage of tin identified on the surface layer.

Preliminary XRF analysis with TRACER 5ⁱ portable spectrometer

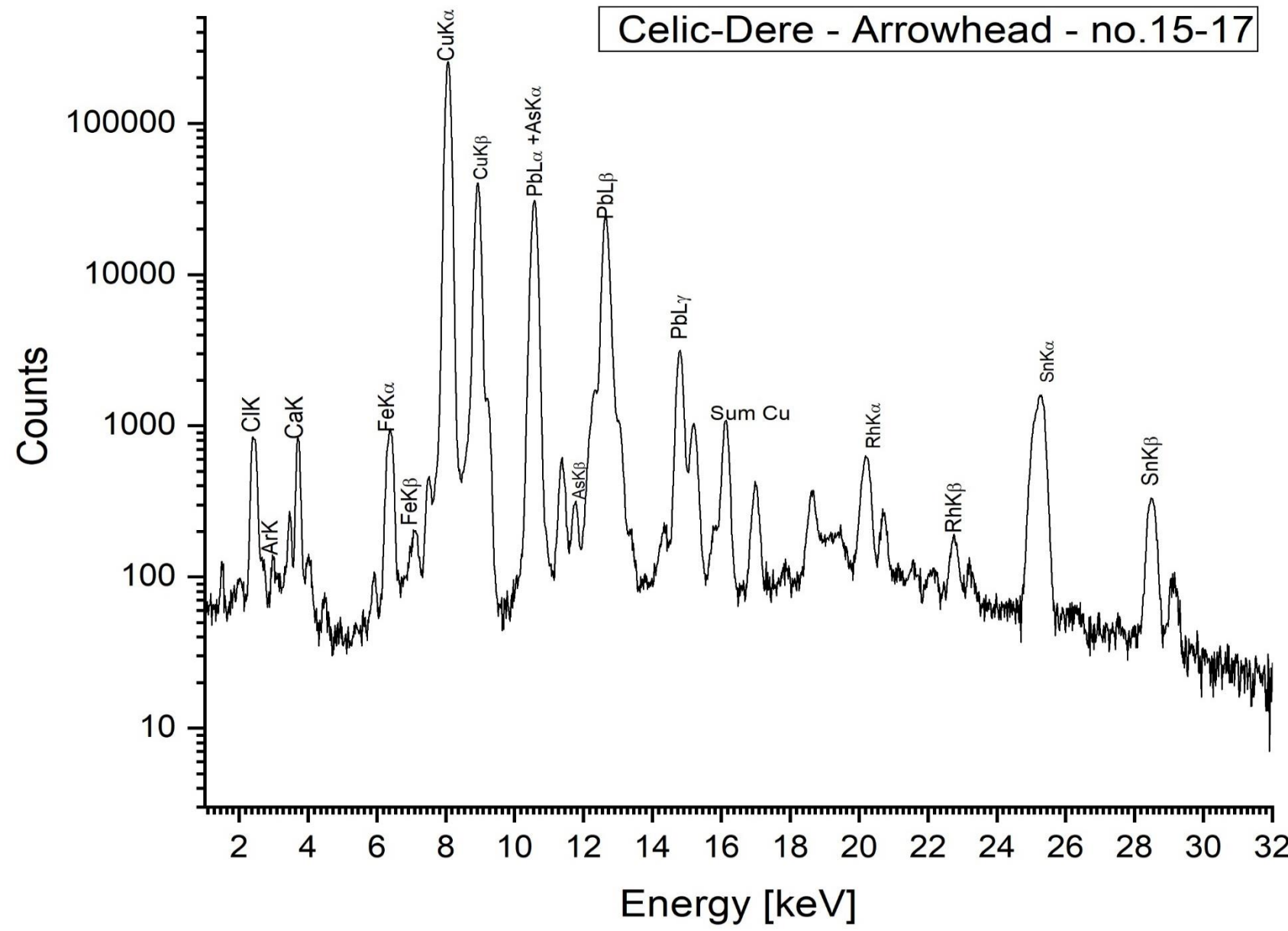
All the items proved to be made of tin bronze, with various other trace elements. The use of a high quality copper alloy is discussed in connection with the intended use of these items as weapons, sources and technological solutions. Also, the variations in the trace elements, leading to compositional clusters, is analysed against the typological variations identified in this batch, in an attempt to determine if there are any trends or reflections of technological choices.

The Cu-Sn-Pb alloy is present in the Celic Dere site.

The analyzed arrowheads come from 7 funerary contexts (graves) and could be clustered into 4 main variants based on typological details. The comparison of the alloy compositions based on association of items inside graves offered no clear connection so far. Due to the comparison of compositions by typological groups (variants) we can observe some technological trends. Variant 1 (12 items) and variant 2 (11 items) are made of tin bronze with traces of Pb (with 3 possible exceptions – Pb around 3% and higher) and As, but Sb below the limit of detection.

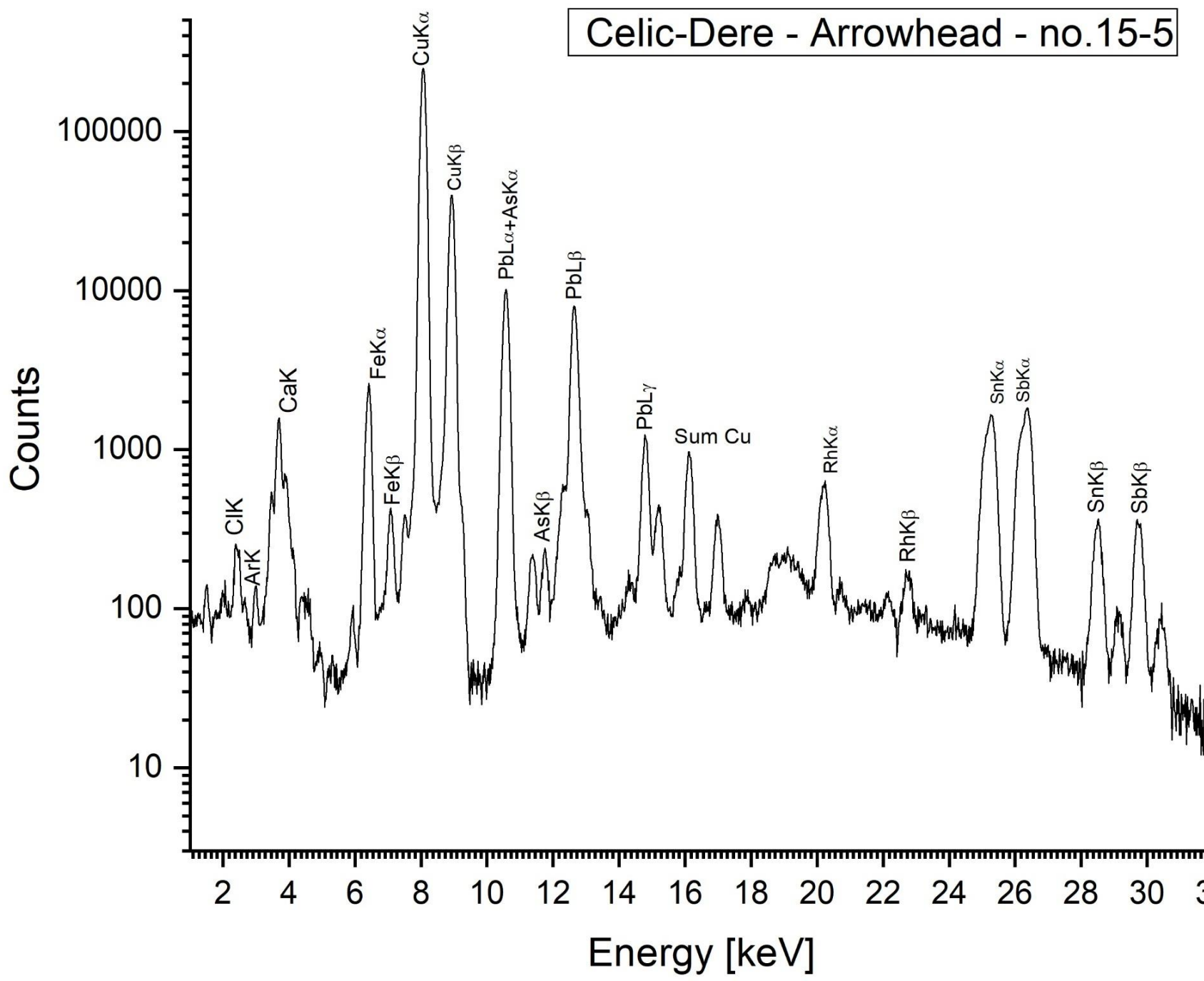
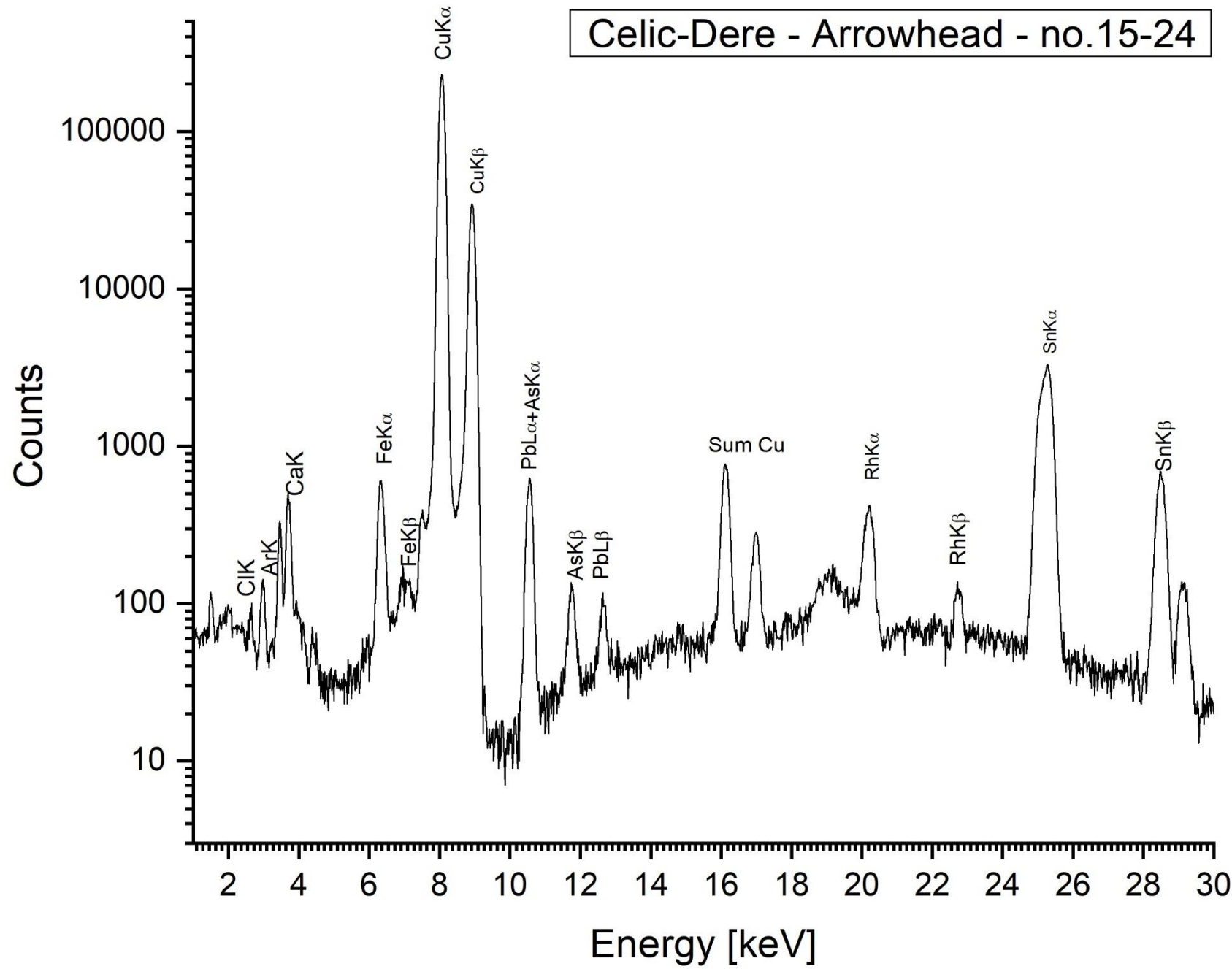
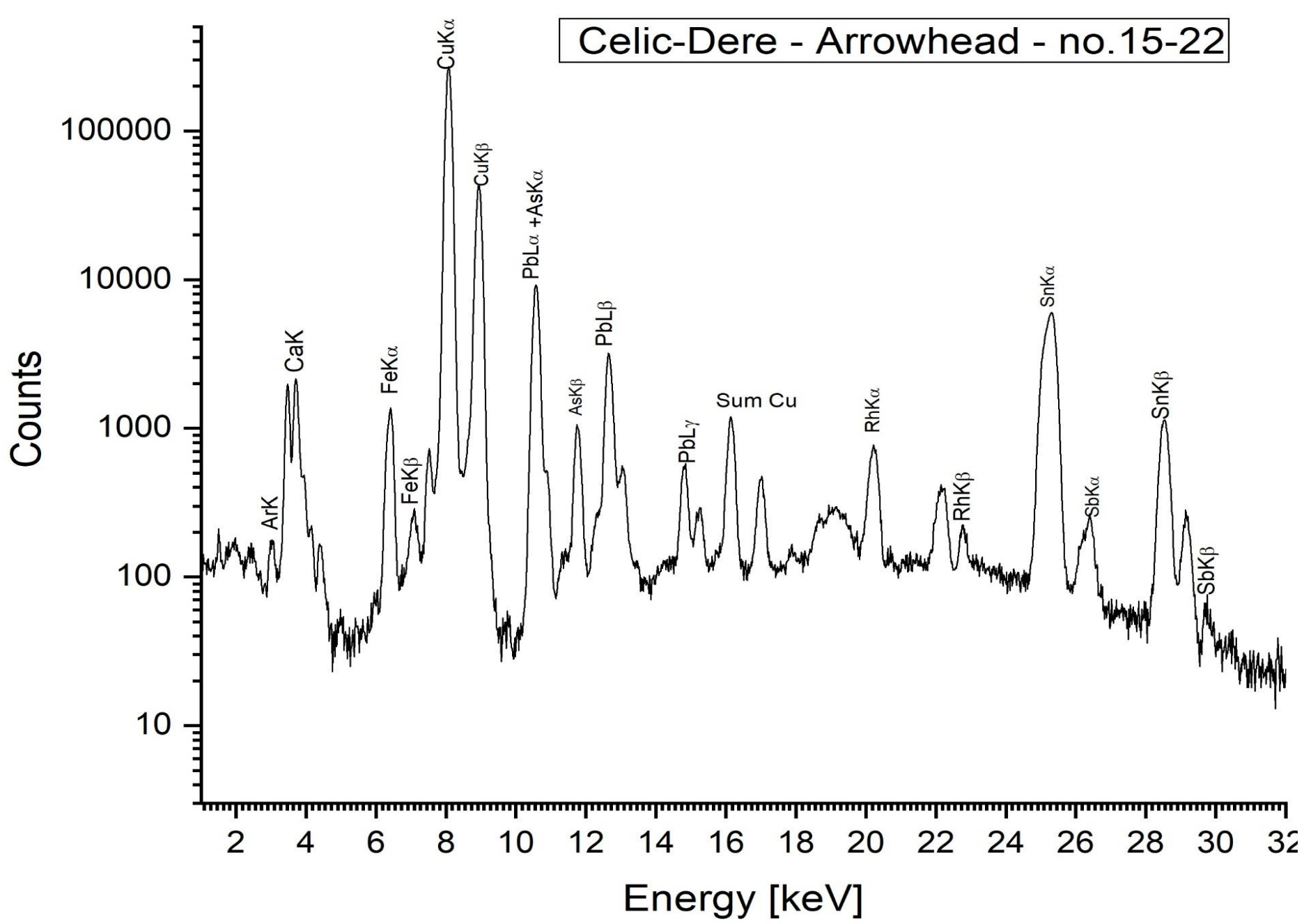


Scythian-type arrowhead from Celic-Dere

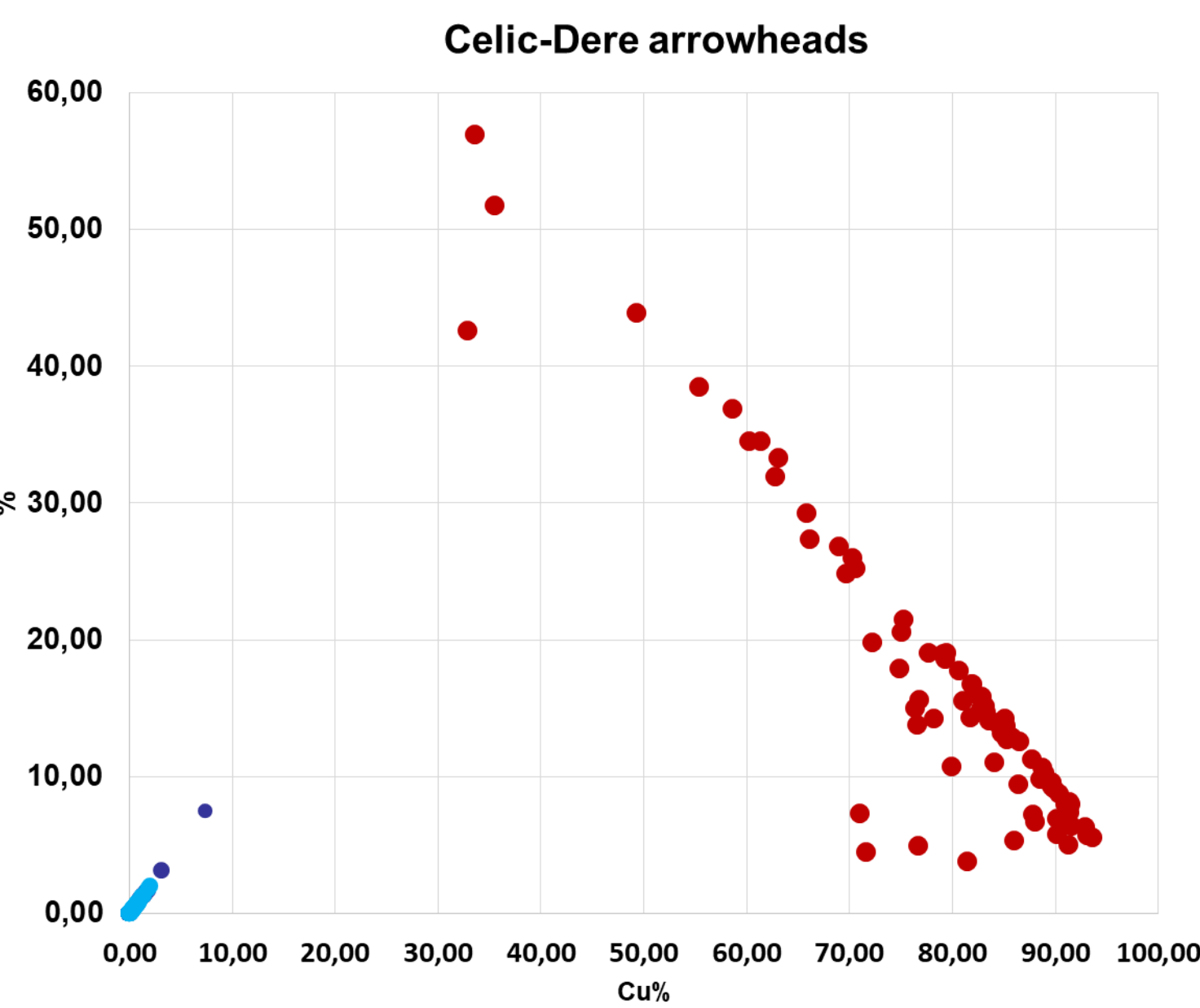


Variant 3 (54 items) is made of tin bronze, but in 17 cases (30% of the items) Pb is present with values between 2.41% and 23.39%.

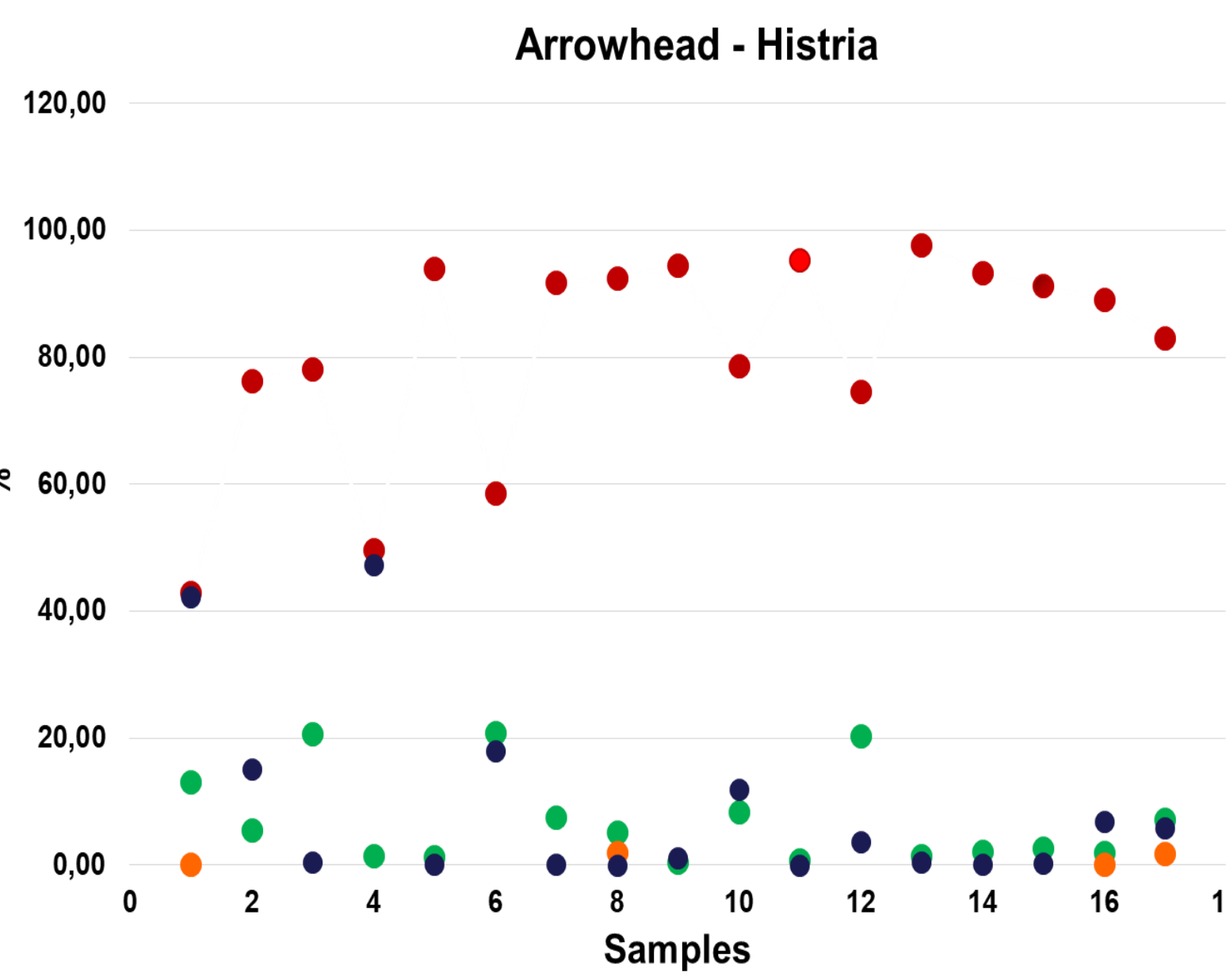
Variant 4 is represented by only 1 item, so it is not statistically relevant.



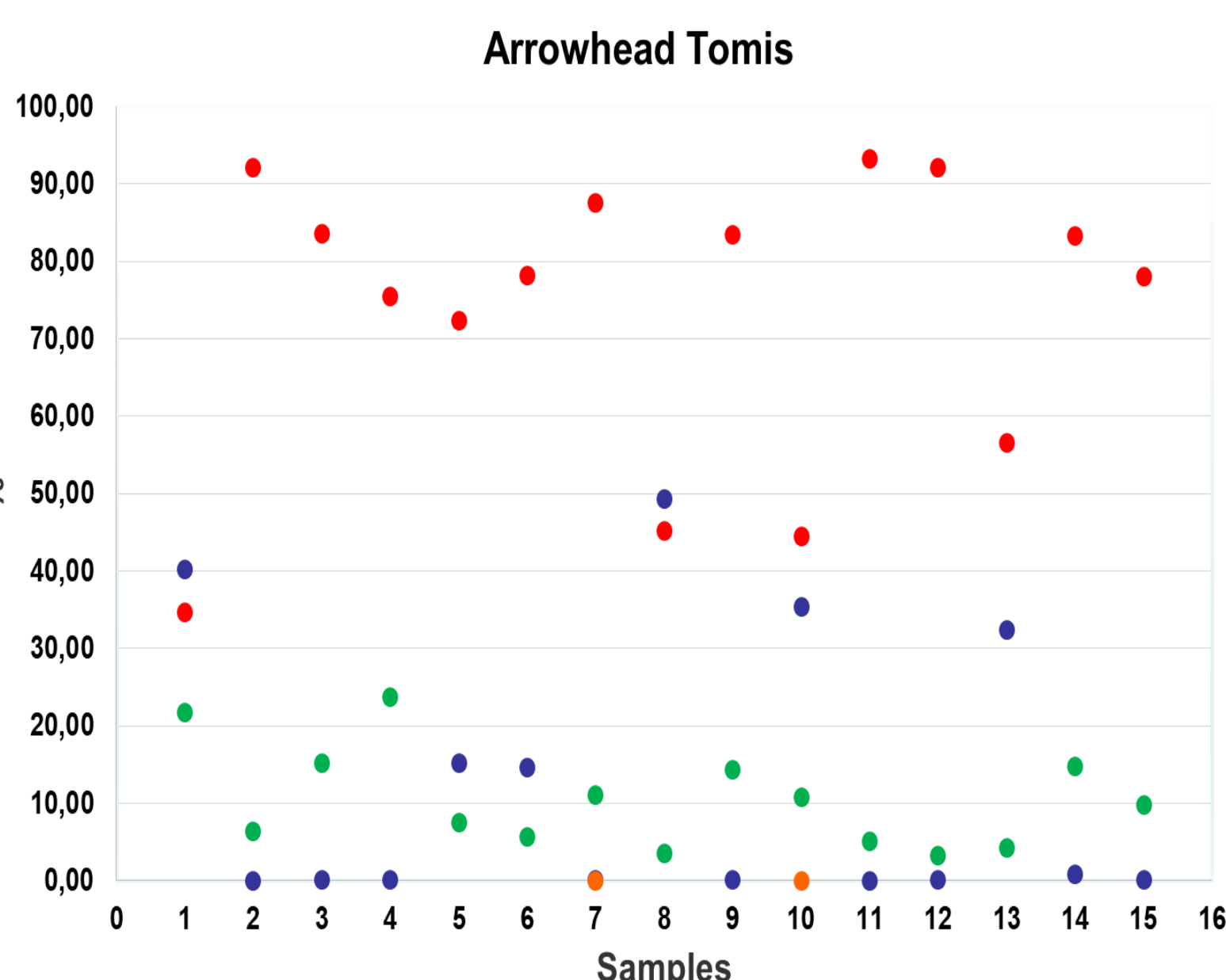
Also Sb is present in 20 cases (almost 40% of the items), for this variant. In 15 cases Sb above LOD (Limit of Detection) is associated with Pb values above 2.41%, a situation which deserves further investigations.



Traces of Sb and As found in arrowheads alloy



The Cu-Sn-Sb-Pb alloy is present in Histria and Tomis sites.



A possible explanation of the compositional trends in connection with the typological characteristics could be their production in different workshops or by different bronzesmiths. Different moments in the production of the same workshop could also be taken into consideration, but the chronological gap must be considered minimal, as these variants were found together in the same grave. The possibility that the arrowheads were produced in the same workshop in parallel, using several different moulds and any source of metal at their disposal is also a strong possibility. Given the fact that arrowheads in use in the Greek colonies of *Tomis* and *Histria* sometimes have both Pb and Sb in their composition, it should be taken into consideration also either the access of the Scythian community to the same source (directly or through commerce/exchange) or the recycling of Greek arrowheads or other bronze objects and the use of metal for their own arrowheads. An alternative would be the access to a Pb ore (but one without Ag) or lead found on the market and experimenting during the production of arrowheads, using the same mould(s) as for tin bronze unalloyed with lead.

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