Mareva Gabillot (ed.), Métallurgistes en France orientale au Bronze moyen. Nouvelles analyses physico-chimiques et morphométriques. Editions universitaires de Dijon, Dijon 2021. € 25.00. ISBN 978-2-36441-401-3. 130 pages with 231 illustrations, mostly in colour, and 6 tables.

This collective volume consists of related but independently written chapters by different authors. They were accumulated under the direction of Mareva Gabillot, who is well known for her studies on the circulation of Bronze Age axes in France and morphometrical analyses of bronzes. Her co-authors Paolo Picardo and Justine Vernet are specialists in chemical and archaeometallurgical analyses, something which is also well attested by their previous work. Jean-François Piningre and Sylvie Jurietti have worked with several periods and materials and have brought the knowledge of regionally specialised archaeologists to the study. Fabrice Monna and Josef Wilczek are experts on 3D applications and computing in archaeology.

The volume provides an insight into the collective research project "Métallurgists en France orientale (Franche-Comté / Bourgogne) au Bronze moyen (1500 avant notre ère)", which started in October 2016 and was funded by UMR 6298 ARTeHIS "Archéologie-Terre-Histoire-Sociétés" CNRS/UB/Culture, Université de Bourgogne / Sciences de la Terre (http://aprab.org/arcab/gabillot.html [last access: 17.02.2023]). It focuses on middle Bronze Age metallurgy, connectivity, and economy in Burgundy and Franche Comté, as well as in adjacent areas. The study aims to investigate bronze artefacts using metallographic, micromorphologic, and chemical methods to identify key characteristics of manufacturing techniques and used alloys to differentiate between local production and imported bronzes. The results should provide a foundation of scientific data for a comparison of bronzes from the Franche-Comté and the Amoricaine regions at the Atlantic coast.

The volume is divided into four chapters, of which the first focusses on the metallographic and microstructural analyses (pp. 19–108). The second concentrates on chemical analyses (pp. 109–118) and the third gives brief insights into the morphometrical work on the bronze objects (pp. 119–124). Chapter 4 tries to summarise the results of these three approaches (pp. 125–127).

In the first chapter, which is by far the largest section, metallography was used to identify skills and production choices of metal craftsmen through the microstructure and macroscopic observations of objects with focus on the *châine operatoire* of the casting process, surface finishing techniques, and use-wear. Eighty-seven bronzes from eight different hoards were investigated, which include axes, bracelets, ornaments, sickles, daggers, ingots, and casting remains. They all belong to the same chrono-cultural horizon and are listed with basic descriptions such as type, current location, and inventory number. Brief information on the find contexts is also given. The obtained results are only presented for the axes and bracelets. The results concerning other artefact groups will be published elsewhere. The motive for this selection is only given much later in the volume (p. 102), where it becomes clear that this choice reflects earlier studies of bronzes from Aquitaine and the Loire-Atlantique region, which also focused on these two object groups. The bronzes were grouped according to their state of manufacture: miscast, rough cast, finished, used, and destroyed. The analyses were carried out using optical and electronic microscopy as well as energy-dispersive spectroscopy. Short explanations of the analytical strategy and nomenclature used in the project are helpful, which is also true for descriptions of the object sampling. The same experimental protocol was used for all objects to confront and correlate the obtained information.

Pages 26–63 contain photographs of all sampled axes (overview and details) and micrographies of their alloys. Nineteen different types of axes were micrographically studied. Mainly tin and lead, the two alloying elements with the most variability, were highlighted and compared with microstructural parameters. One axe from the hoard of Prétin contains the lowest tin values of the set; the lowest lead contents, on the other hand, are distributed across different find ensembles. Both

elements allow a distinction between the alloy of the axes "à aileron naissants" and axes "à talon" within the eastern and central hoards. Axes "à talon" were manufactured by an alloy richer in tin than the first group. Therefore, a division between regions which is rooted in typology is proposed. No correlation between lead and the other variables (axe typology, finds, tin content) can be considered. One axe "á talon" from Marnoz (M-8) is a hybrid form, with typical attributes of eastern types and fits compositionally into the cluster of the typologically different axes "a ailerons naissants". It is stated that it would have a higher lead content (c. 2 % mass.) than all other objects (65), which is confusing, since in the table at page 65 the axe from Marnoz has 9.2 % tin but only 0,6 % lead, which is not higher than the other bronzes. It remains unclear which axe the authors could possibly be referring to, since the only axe with a lead content of almost 2 % is one from Prétin (M 1/19), but it has only a comparably low tin content of 5.1 % and therefore also does not fit the description.

The microstructure of the analysed samples shows either monophasic or biphasic matrices, allowing the authors to group the alloys according to low, middle, and high tin contents. The results of the analyses are not surprising; three methods of bronze working are detected: a lateral reworking of the edge at axes "á ailerons naissants"; a reworking of the casting jets on oriental type axes; and a reworking of the cutting edge on Norman type axes "á talon". All of these steps are also macroscopically detectable through hammering marks on the artefact surface. The combined results of the microscopic examinations and the surface observations show, rather unsurprisingly, that axes were either partially, completely, or barely reworked. Why exactly the dendritic microstructure with slight surface deformation, indicating polishing, would indicate the single-use of a mould is unfortunately not explained and might have been worth a few more words. In a second step, these results are correlated with typological aspects of the axes and their geographical area of discovery (Atlantic domain, Eastern domain). It is stated that no clear distinction between the regions can be made, because the axes show all kinds of technical facets – strong, as well as light, or no structural impacts.

A similar protocol that was used for the axes was implemented in order to investigate the nine bracelets, which are typologically divided into massive rings with a round section, hollow rings with decoration, and massive rings with a D-shaped section. Pictures of the microsections and an evaluation of the microstructure of each object cover the pages 70–87. When studying the bracelets, the authors focus exclusively on the comparison of the tin content and microstructural parameters. This deviation from the original procedure is a little surprising, as the lead content does not vary as much as within the axes, but neither does the tin content. No regional trends in the chemical composition of the alloys seems to be discernible (p. 88). Again, single-phase or two-phase metal matrices are detected. A previous technological study of some twenty examples of massive bracelets in another project is quoted, which identified two manufacturing techniques: 18 out of 21 bracelets were reworked and underwent mechanically plastic deformation done by a succession of hammering and annealing. The amount of chiseled decoration was highly variable (C. Lagarde-Cardona, Production métallique en Aquitaine à l'âge du Bronze Moyen. Techniques, usage et circulation. Scripta Ant. 39 [Bordeaux 2012]). It is concluded that the same technical know-how can be found in bracelets of different regions and variants, which fits well with studies of other European bronze artefacts.

Sadly, the photographs of the sampled bronzes (pp. 91–101) are all unsharp, which is a pity since they are printed in colour on high quality paper. This is particularly irritating since the micrographies are of good quality. A similar problem arises regarding the drawn images of bracelets (p. 104 fig. 44), which makes a proper evaluation of the items, in particular their typological or stylistically differences, impossible. Again, a consultation of further publications to get an impression of the finds is necessary. It is also not ideal that one needs to use other publications to get an overview of all the materials included in the analyses. There are no figures of the hoards investigated in previous

studies, which were used for comparisons and included in the presented results. This is a bit frustrating since the volume generally focuses strongly on the graphic representation of the examined finds.

Three major conclusions are drawn in this chapter: First, the homogeneity in the manufacture of axes in the eastern and south-western domain illustrates a specific and common technical know-how regardless of the type. Second, the technical features of the axes can be linked to certain regions with specific know-how; these regions may be understood as production centres for regional models and the imitation of types from neighbouring regions. Therefore, the manufacturing method is considered a better indicator for the object's geographical origin than its morphology. Unfortunately, it is not clear what the authors mean with the term "production centres". They do not seem to refer to particular settlements or workshops but use the term more in a regional perspective. Further investigations about whether these axes were made in Burgundy-Franche-Comté with local ore or whether they were imported in a raw state and then reworked by hammering are required. Regarding the bracelets, the authors' interpretation goes one step further when they postulate a mass-production of rings, which could be personalised at a later stage on request in a workshop. This is an intriguing idea, which has been also formulated for early swords of the Carpathian basin, which belong to a similar chronological horizon (B. Nessel / E. Pernicka, Aspects of the metal supply between central Europe and the Carpathian Basin in the Early and Middle Bronze Age. In: J. Maran et al. [eds], Objects, Ideas and Travelers. Contacts between the Balkans, the Aegean and Western Anatolia during the Bronze and Early Iron Age. Universitätsforsch. Prähist. Arch. 350 [Bonn 2020] 357–370).

The second chapter concerns the chemical analyses of 142 samples from different hoards, selected and prepared for elemental analyses in 2006, but first analysed in 2016 using ICP-AES. It is confusing that suddenly analyses were made of bronzes from completely different find spots and regions than in the first chapter. Elemental analyses were carried out to group objects according to their chemical signature and provide information on the ore type. The results were processed by principal component analysis (PCA) to identify groups of objects with similar characteristics. It is stated that 136 bronzes of different types and functions have the same chemical signature. A total of 120 of them are from the initial list and 16 new samples are obtained from the Vic-de-Chassenay hoard. Why eight samples are completely missing remains unclear. The results of the PCA are illustrated by a dendrogram, which shows the general distribution of the values sorted after the best possible statistical classification. No family corresponds to a single hoard, which shows that none of the complexes can be attributed to one workshop (using the same ore) and that there is no correlation of types. Unfortunately, the dendrogram is much too small and unsharp, which makes it almost impossible to read the labels.

In the following, it is stated that the first tests would show that objects of the Atlantic types are different from the Continental types, but the results cannot be provided, since the copper ingots first need to be separated from the bronze ingots (p. 117). It could have been emphasised that the Continental group is chemically much more variable than the Atlantic group, a characteristic which will remain as a result, regardless of whether the copper and bronze ingots are separated or not, since the majority of these form a separate group in the plot anyways. It is noticeable that descriptions of the used statistical methods and their potential are scarce compared to the first chapter.

Agisoft Photoscan was used in the third chapter concerning morphometry, together with PCA, multivariate variant analysis, and lineal discriminant analysis. 3D models were produced for 125 bronzes from different hoards. The aim was to measure the morphological relationship between ingots and axes to see whether both groups were distinct from each other. The measurements showed that axes and axe-shaped ingots are clearly different in shape even when they belong to the same find, which suggests close contacts in the region between Dijon and Lyon in the field

of metallurgy. At the same time, the metallurgical complexity of the hoards is stressed, and the authors denied that the Granges-sous-Grignon and Vic-de-Chassenay hoards could be the product of one craftsman or workshop because different and identical objects were distributed among them. Similar observations are known from different finds all over Europe, and the organisation of metal circulation is usually very complex. Hoards, which only contain artefacts made from the same alloy are very rare in this horizon, if they exist at all.

The final chapter attempts to combine all three approaches in order to come to some general conclusions. However, instead of actual reflections and combined conclusions based on the archaeological and scientific results, it is more a summary of statements made in previous chapters. Essential points are that macroscopic observations, metallography, and chemistry should be compared in order to determine workshop zones that can be distinguished by certain parameters such as the manufacture of objects, the acquisition of raw materials, the use of moulds, etc. Macroscopically similar or even identical objects are considered to be made by the same craftsman or a "school of manufacture". Therefore, this similarity is assumed to be present in chemical, metallographic, and morphometric characteristics (p. 125). This underlines the need for scientific studies on bronzes. That being said, the final conclusion is at odds with the opening statement, which is that the use of elemental chemistry and trace element analyses is impaired by a lack of precision to answer the questions raised and are therefore unreliable. Besides the fact that no deviations are given in any of the plots, which means that the precision of whatever method used cannot be assessed, it is confusing to read such thoughts first thing on the penultimate page of the volume. The authors favour metallography as the most suitable method to answer their questions because a single sample would be sufficient to obtain all results of interest without the supplement of elemental chemistry and lead isotope analyses. It remains unclear to me how the potential of lead isotopes is sufficiently realised in metallography.

The actual purpose of this volume remains somewhat unclear. One searches in vain for combined results, but only the goals of the project become clear. It seems to be more a presentation of the potential of modern technology used on archaeological bronzes. The independent composition of chapters makes it hard to gather and combine all information about one object or find ensemble. That the bronzes differ in number and find association in every investigated sample set, and that only a part of the items are depicted, does not help in this respect. The connection between the photographs and the text passages is lacking in some cases, amplifying this impression.

However, the publication of interdisciplinary studies is always of high value. The comparability of the results will provide a stable foundation for further research on the circulation of bronzes and the organisation of metalwork. The methodological explanations for the metallographic and microstructural analyses are very helpful, which is not self-evident and shows that the authors rightly enjoy their reputation.

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