A new Multivariate Approach for Identifying Provenance: a Description of the Ariège Iron Market in the Middle Ages

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Abstract

In the Middle Ages, the iron market within the Ariège (French Pyrenees), and nearby, is difficult to make restitution since it was dynamic and complex. Numerous iron objects discovered on archaeological sites (13th- 15th c.) within this area but also construction irons found in medieval buildings were studied by INAA, ICP-MS, LA-ICP-MS to determine their origin. Due to the complexity of the high dimensional data set acquired, an ad-hoc multivariate statistical method was developed. This procedure was applied to determine the compatibility of the artefacts of unknown origin with a provenance from Ariège. Provenance results allowed to supply a crucial complementary data of historical sources and to better apprehend the Ariegean market.

Introduction

The clarification of geographical provenance of ferrous archaeological products seeks to increase a better knowledge of the history of techniques and economy. The aim of this work is so to clarify the trade routes and the diffusion of ferrous materials inside the production space of the Ariège (the French Pyrenees). This region exploited manganese rich ores. A historical study founded on documentary sources, permitted to shed light on the iron-making activities in this area from the 13th to the 16th centuries [1]. The iron circulation in this production space is particularly hard to grasp due to the complexity and the dynamism of the iron market.

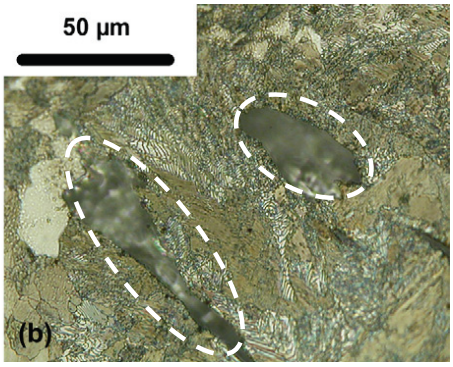

Fig.1; SI= second phase particles coming from the non reduced compounds of the ore and entrapped in the metallic matrix.

Several studies have recently highlighted the fact that the Slag Inclusions (SI), embedded in the metallic matrix during solid state reduction processes, contain crucial information on the origin of iron artefacts made by the bloomery process (Fig.1). The provenance can be therefore followed by first determining specific trace elemental signatures of the supplying regions, then by following these signatures into the SI remaining in the ferrous products [2, 3]. The elemental signature of an iron-making area can be defined by analysing ores, slags and semi products from archaeological sites of this area.

Materials & Methods

To obtain quantitative chemical information on major and trace elements in archaeological samples, different methods such as SEM-EDS, INAA, ICP-MS and ICP-MS with laser ablation were used. Then, a reference set of samples has been first gathered for the determination of the chemical signature defining the Ariège area. This has been done by analysing collected ores, slag

samples and iron products from geological and archaeological sites of this region. In order to study the iron market in Ariège, well dated objects of unknown origin (13th -15th c.) from various castles were selected. The origin of construction irons used in the Capestang collegiate church (14th c.), situated at more than about a hundred kilometres of the production space of Ariège, was also studied. In total, numerous archaeological samples (~250) were analysed in this provenance study, which provided a very large data set. If the recent studies designed to determine the origin of iron objects have been based on the analysis of trace elements, they did not make good enough use, to date, of the great amount of elements (13 trace elements) selected to chemically characterize the iron-making areas. Consequently, it was necessary to set up an ad-hoc methodology in order to treat the substantial amount of analytical data acquired. To this aim, a multivariate statistical method combining a specific raw data transformation and multivariate analysis is proposed to determine (or exclude) the provenance of iron artefacts. Since there are much more data that define the Ariège area than the artefact itself, a supervised analysis like LDA permits a more efficient treatment than unsupervised ones. Indeed, due to its principle of exclusion, LDA can separate easily the chemical signatures of two groups of samples with a different origin.

Results

The application of the multivariate methodology to the variables characterizing the iron-making Ariège area and objects of known origin permits to define an abacus of provenance compatibility, established from the absolute values of the variables' projections on the discriminatory axis (LD1) (Fig.2). This abacus underlines different compatibility domains (compatible, undetermined and incompatible) of the chemical signature of the object of unidentified origin with the Ariège area's one. It allows to compare the chemical signatures and, subsequently, to test the provenance hypothesis.

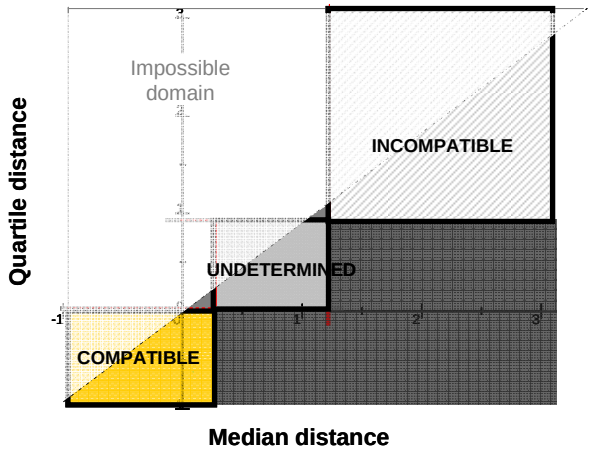

Fig.2; Provenance compatibility abacus showing three particular domains of compatibility with a provenance from Ariège.

Conclusions

This paper demonstrates the efficiency of the method in excluding and validating a potential provenance. Basing on the abacus, certain characteristics concerning the circulation of iron products in Ariège were reconstructed, therefore confirming some historical hypotheses. We were able to illustrate the fact that Ariège, in addition to being an effective production area, was also a market area where products of different origins were exchanged.

References

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