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## Modelling ancient Bronze craft techniques in Italy. From ore to object and back

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### 00 INTRODUCTION

The ongoing ANR JCJC Itineris project (<https://itineris.humanum.fr/>) focuses on the characterisation of Italic bronze craftsmanship by combining archaeometric, mathematical and computer modelling methods with social and archaeological approaches. The aim is to revise and model cultural interactions in Europe during the Early Iron Age. The Archaeometric approach (WP1) point to determine the chemical composition of raw materials, verify the possible existence of multiple active workshops and try to finding of copper supply sites.

### 02 METHODS

#### SAMPLING

12 items for lead isotopic analysis (LIA) and chemical analysis (MC-ICP-MS, Bochum) and 20 items from the same collection and cultural group for chemical analysis (MC-ICP-MS, C2RMF). The items are binary bronzes: Cu + Sn (Sn 3.05 - 10.86 wt %). Pb value is on average 1%, the isotopic analysis is possible to performing (no voluntary addition). Bi, As, Ag, Sb, Ni are the most relevant impurities.

#### DATA PROCESSING

The Cross-referencing LIA, geochemical and ICP results with the **AAcP database**<sup>1</sup> of Padua University to locate the ore provenances (Artioli et al. 2016). Isotopic data from the Chiusa Pesio hoard (Late Bronze Age, Venturino 2009) are also used to complete the archaeological, chronological and archeometric framework.

<sup>1</sup>: <http://geo.geoscienze.unipd.it/aacp/welcome.html>

#### DATA MODELLING

Development of a framework linking statistics and network analysis of archaeometric and archaeological data using web-based open-source softwares (R package **itineRis**, 3DHOP viewer) and shared platforms (Github, GitLab) for FAIRability of research products, versioning and interactivity.

### 04 DISCUSSION

The cross-referencing the first results - LIA and geochemical - from Chiusa Pesio, Golasecca area (both NW Italy) and Hochdorf seems to suggest a difference ore provenances for these productions :

→ Late Bronze Age ore from Chiusa di Pesio (**purple stars**) are Alpine: mining districts of Chialamberto and Val di Susa. (Artioli, in Venturino 2009)

→ First Iron Age ore of Golasecca culture (**yellow stars**) seem to have at least three sources: (A) Alpine, **but different from Chiusa Pesio**, (B) Iberia IPB, and (C) Franco-Swiss. Only one fibula point to Tuscany region. They are overlap well with those of Hochdorf (**red stars**) but those of Hochdorf cover a wider field than the Alpine field (**blue ellipse**) and extend into the **red field** (Iberia IPB) and in the **green one** (France-Switzerland). (Modarress-Tehrani 2021)

→ open source softwares (OSS) and workflows integrating a multiscalar approach (from the sampling location on a 3D model to multifactorial analysis) improve the processing data phase as well as the FAIRability of research results (Cicolani et al. 2023).

### 01 DATA SET

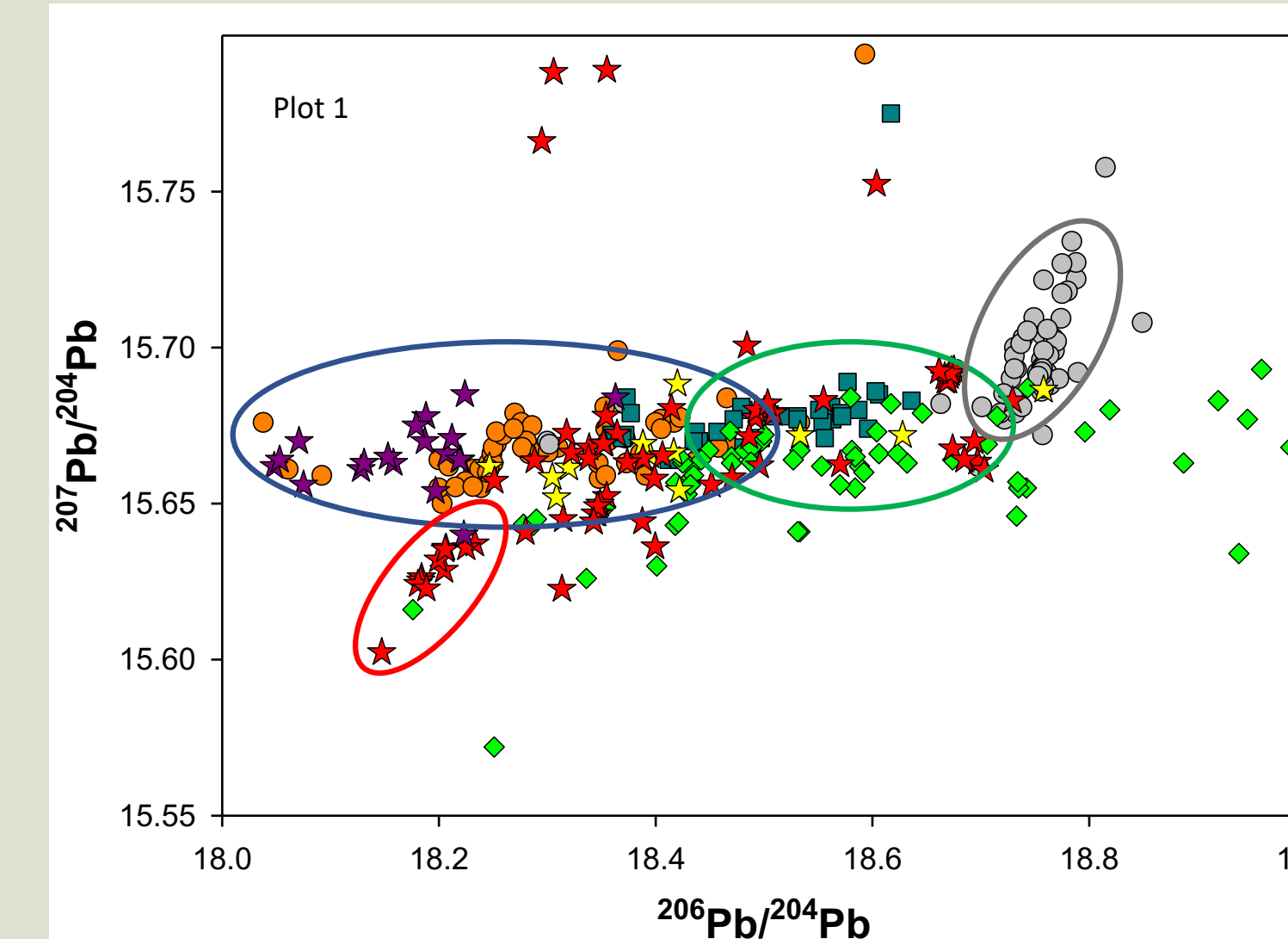
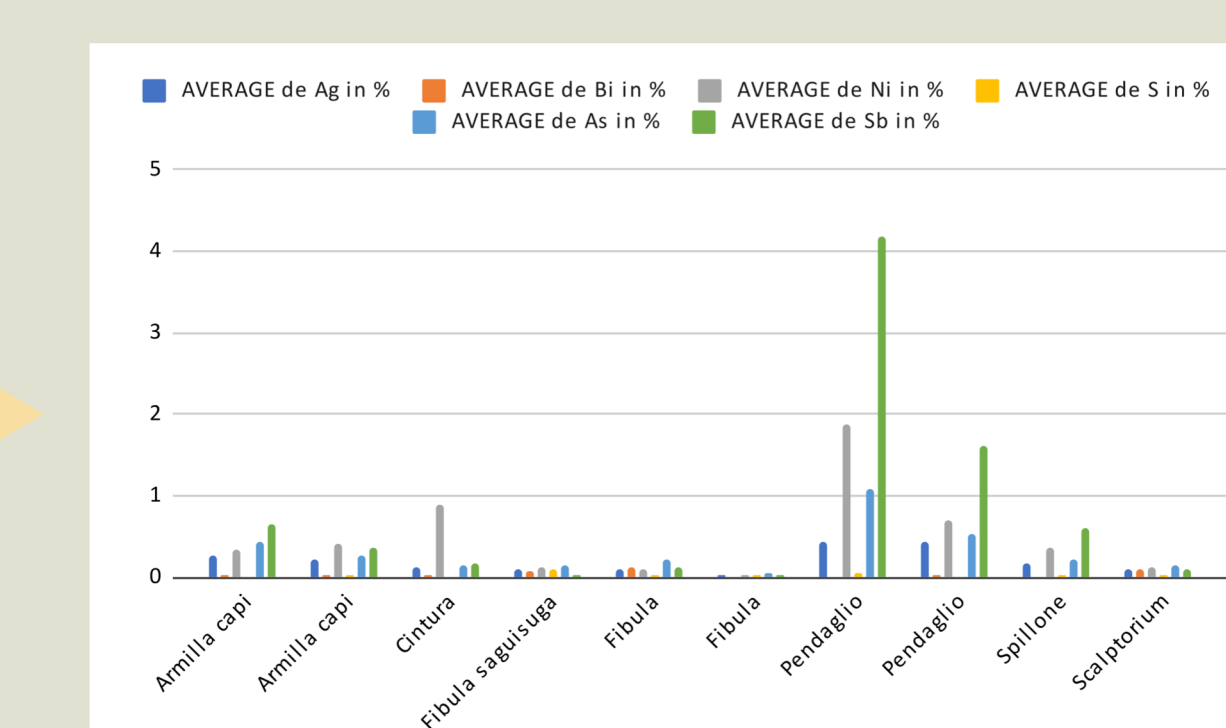
12 copper-alloy objects held in the Musée d'Archéologie nationale of Saint-Germain-en-Laye (MAN) and sampled in the framework of the DFG project Die Sitzbank von Hochdorf (Modarressi-Tehrani 2021) were selected. 20 other objects also held in the MAN will be added to extend and consolidate this dataset. The set is composed of fibulae and clothing items as belt, pin and arming attributed to the 7th and late 6th century BC and belonging to the Golasecca culture (Northwestern Italy), whose productions spread across the Alps in the Celtic area during the Early Iron Age (Cicolani 2017).



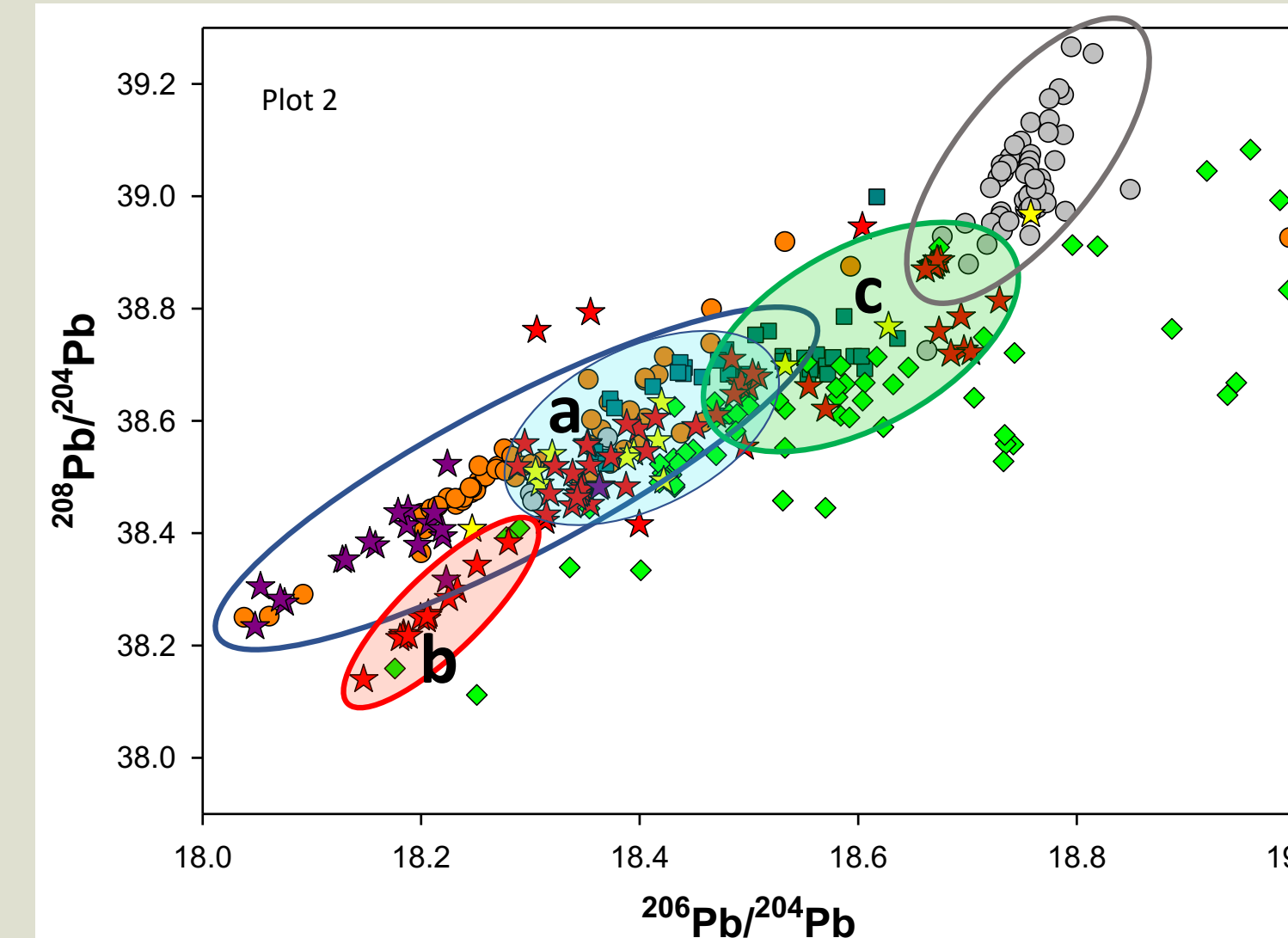
### 03 FIRST RESULTS

Items	Pb208/Pb206	Pb206/Pb204	Pb207/Pb204	Pb208/Pb204	Pb207/Pb206	Pb204/Pb206	Pb in %	Cu in %	Sn in %
Belt	2,09536	18,39467	15,66543	38,54343	0,85163	0,05436	0,64	87,41	10,38
Toilette	2,08121	18,62780	15,67192	38,76833	0,84132	0,05368	2,97	88,59	7,76
Pendentif	2,10218	18,24669	15,66178	38,40751	0,85834	0,05480	1,57	91,50	3,59
Pin	2,10218	18,30860	15,65197	38,48796	0,8549	0,05462	0,45	88,27	9,77
Fibula	2,10377	18,31990	15,66153	38,54087	0,85489	0,05459	1,39	88,55	9,47
Pendentif	2,1038	18,30471	15,65851	38,50947	0,85544	0,05463	1,11	87,68	3,05
Arming	2,09405	18,41662	15,66637	38,56541	0,85066	0,05430	1,39	87,19	9,97
Fibula	2,08804	18,53334	15,67191	38,69840	0,84561	0,05396	2,82	85,29	10,86
Fibula	2,07741	18,75792	15,68649	38,96794	0,83626	0,05331	1,07	91,17	7,56
Arming	2,08955	18,42200	15,65426	38,49362	0,84976	0,05428	0,38	88,08	10,16
Fibula	2,09563	18,38820	15,66912	38,53489	0,85213	0,05438	2,44	88,97	8,06
Fibula	2,09734	18,42005	15,68839	38,63301	0,8517	0,05429	0,28	89,16	10,38

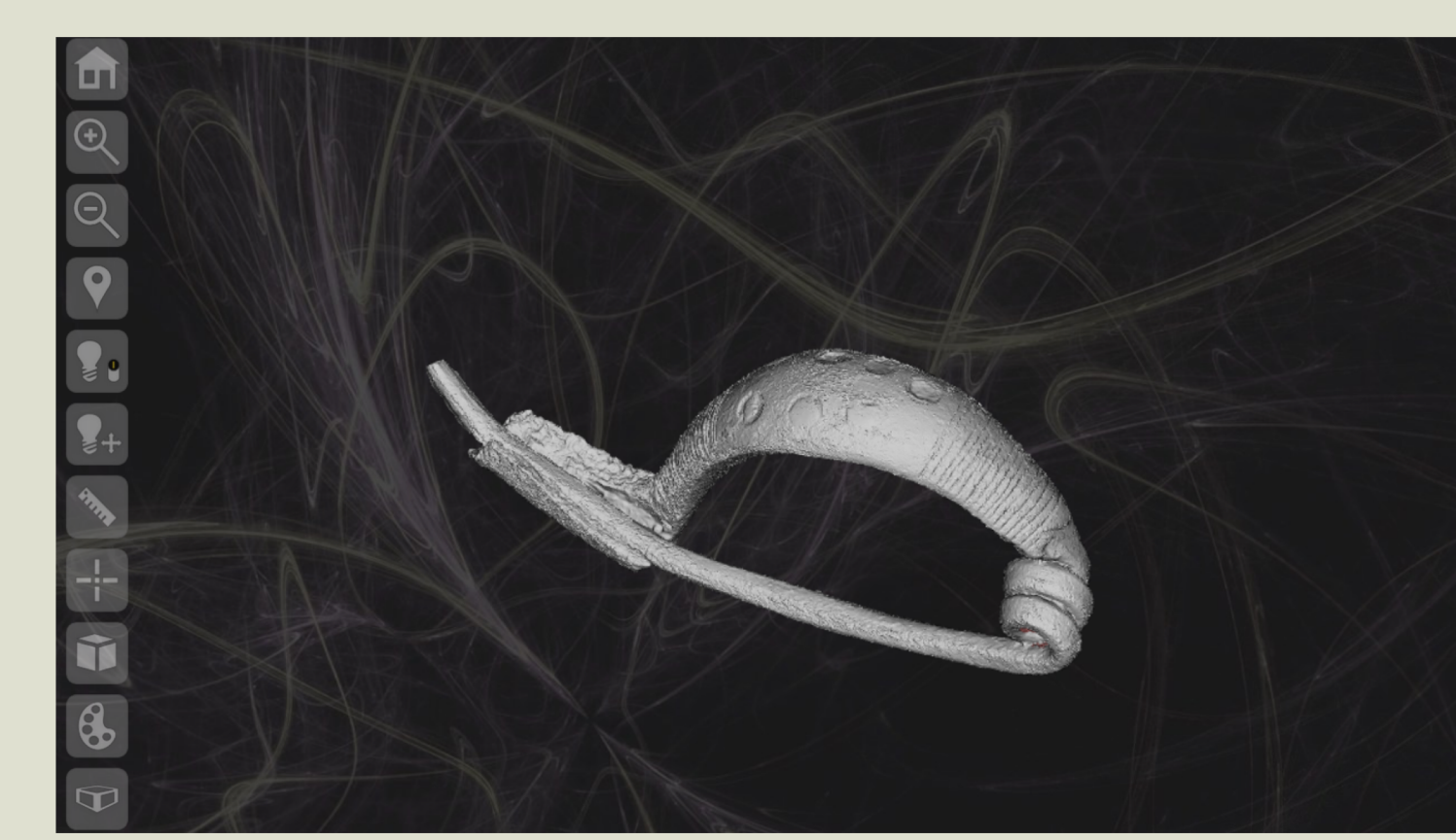
Alloy composition



Mining areas :  
 (a): Alpine  
 (b): Iberia IPB,  
 (c): Franco-Swiss  
 (d): Tuscany  
 Artefacts (stars)  
 Yellow: Golasecca;  
 Red: Hochdorf  
 Purple: Chiusa Pesio

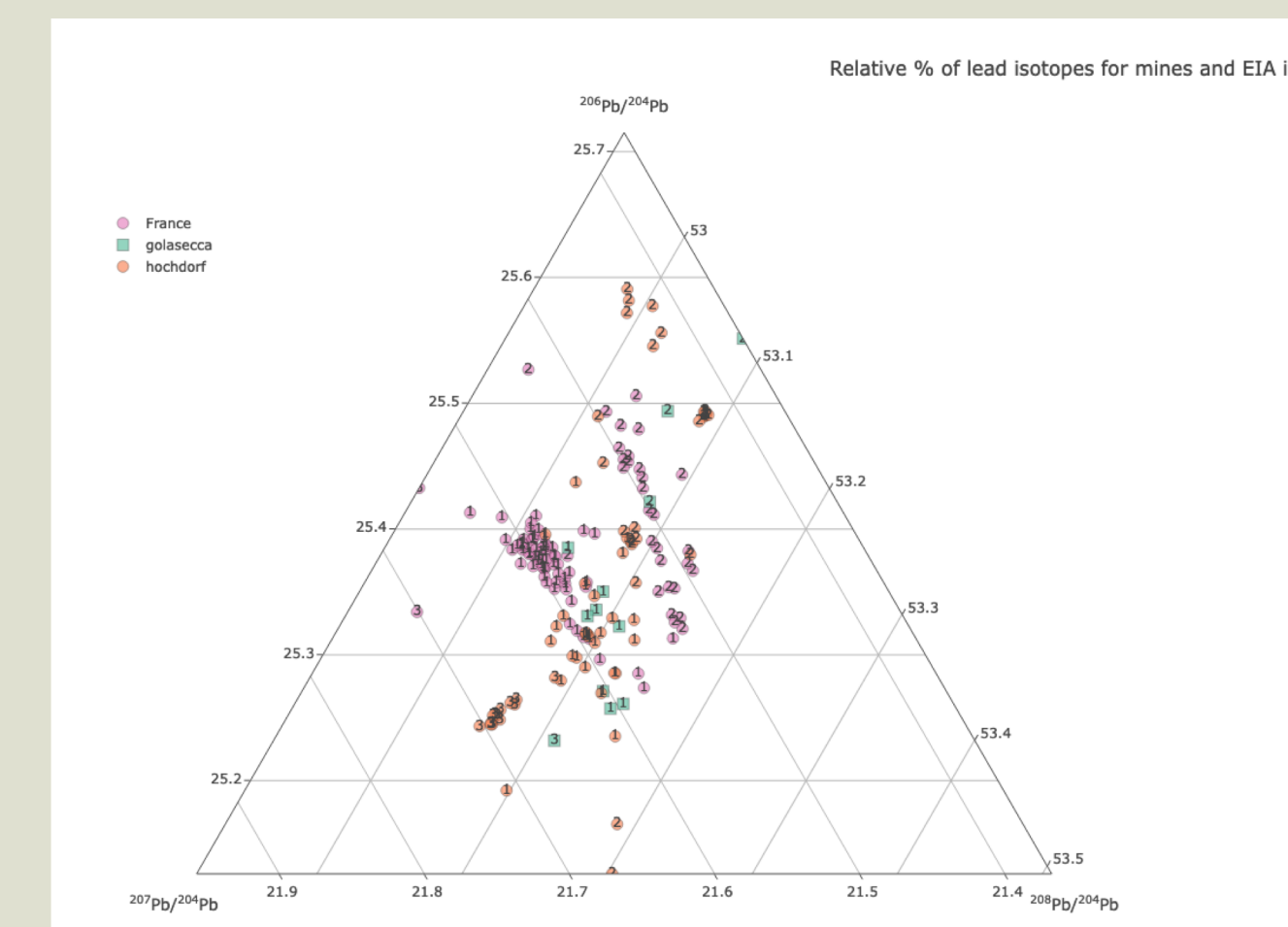


blue circle: Alpine area; red circle: Iberia IPB; green circle: France-Swiss area; gray circle: Tuscany.



Non-textured 3D fibula (3DHOP) with interactive location of sampling and results sharing box.

interactive ternary graph, built with the R itineRis package, to display the results of the lead isotope analysis (LIA).



### 05 CONCLUSION

• This ongoing analysis seems to highlight a first change between the Final Bronze Age and the Early Iron Age on ore sourcing strategies. For the Alpine area, the preliminary LIA results suggest an exploitation of a more limited western Alpine mining districts than Hochdorf. The mining districts exploited in the Late Bronze age in the SW Piedmont do not seem to be used by Golasecca communities during the First Iron Age. The ongoing elemental analysis will provide useful feedback on the geochemical characterisation and thus on the identification of the most promising mining districts used during the First Iron Age.

• Using and developing a formal multi-proxy approach, the Itineris project will provide a thorough and critical review of traditional markers and approaches already applied to the identification of past human mobility. Thanks to the extension of the reference framework and the multiplication of comparisons with other productions from the same archaeological contexts, this project will allow a better understanding of the sourcing and production strategies developed by the Northern Italian communities and their interaction modes, during the First Iron Age across the Alps

CONTACT : <https://github.com/ANR-Itineris>

