

Introduction:

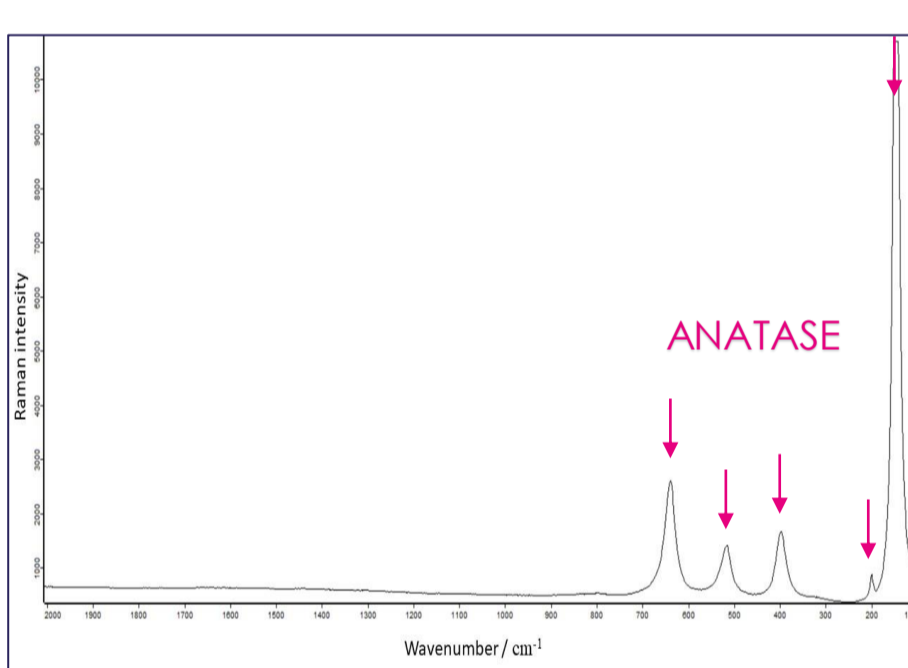
In Northern Italy, presence of whitish decorations on bronze artefacts dating back to the Iron Age is well documented, as in the case of leech fibulae with circular inlays [1] filled with denatured red coral, bleached over time and displaying nowadays a dull white hue.

The archaeological site of Parre (BG) is known for the discovery of a conspicuous bronze hoard at the end of the 19th century. Further excavations performed by the Superintendence of Lombardy uncovered there an important Iron Age settlement [2]. Among the various bronze artefacts, 13 fibulae were selected for analysis due to presence of linear and geometrical whitish decorations. In particular, most of these decorations display an unusual brightness with respect to the other artefacts of comparable chronology – even reminiscent of the white ink often used in the marking of archaeological finds (“White Indian” Ink).

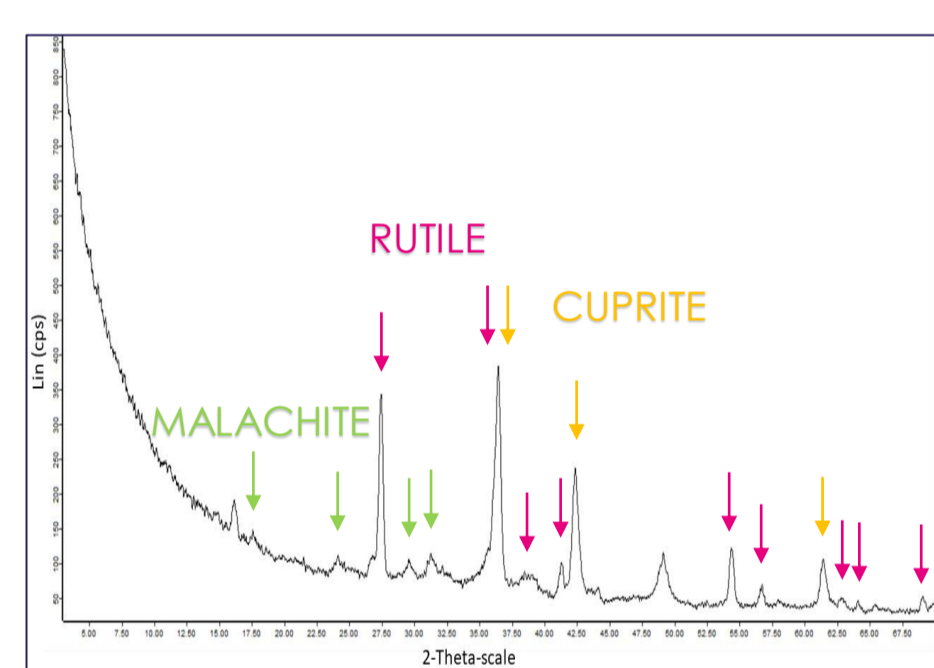
The aim of this work is to verify the actual nature of these decorations, by applying a totally non-destructive multi-analytical archaeometric protocol, aimed at certifying their authenticity or rather identifying more recent conservation/restoration interventions.

Material & Methods:

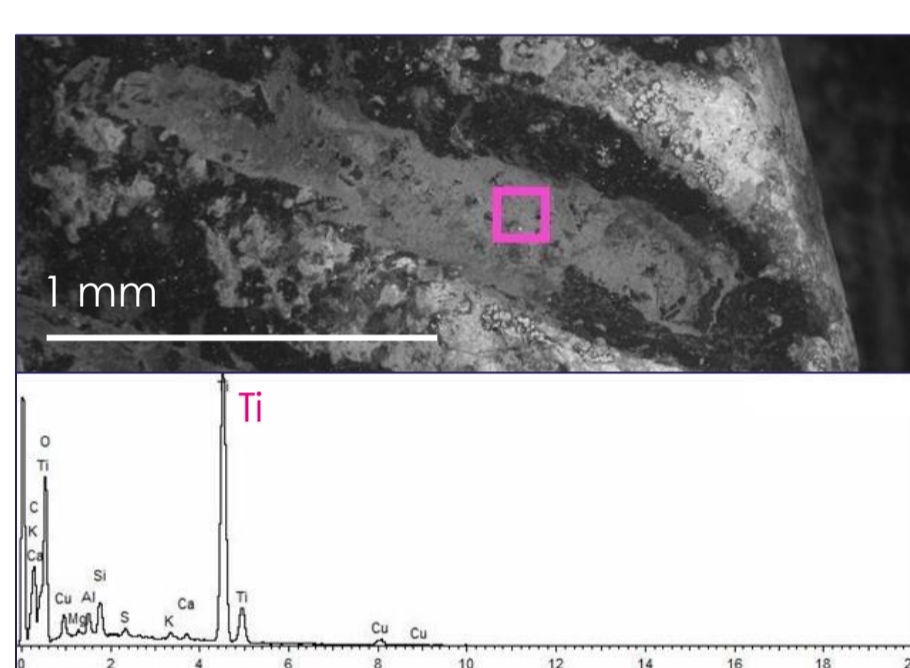
The non-invasive analytical protocol developed for the characterization of red coral inlays on bronze artefacts was applied [3], which involves optical microscopy, μ -Raman spectroscopy, μ -X-ray diffraction and scanning electron microscopy with EDS.



Raman spectrum of inv. 41 decoration.



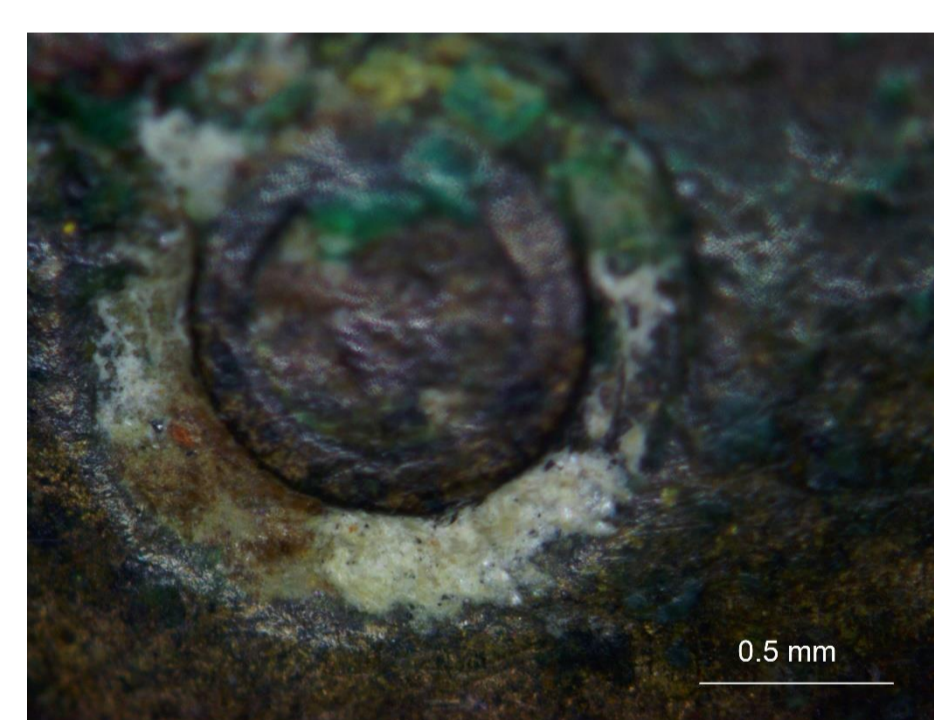
Diffraction pattern of inv. 119 decoration.



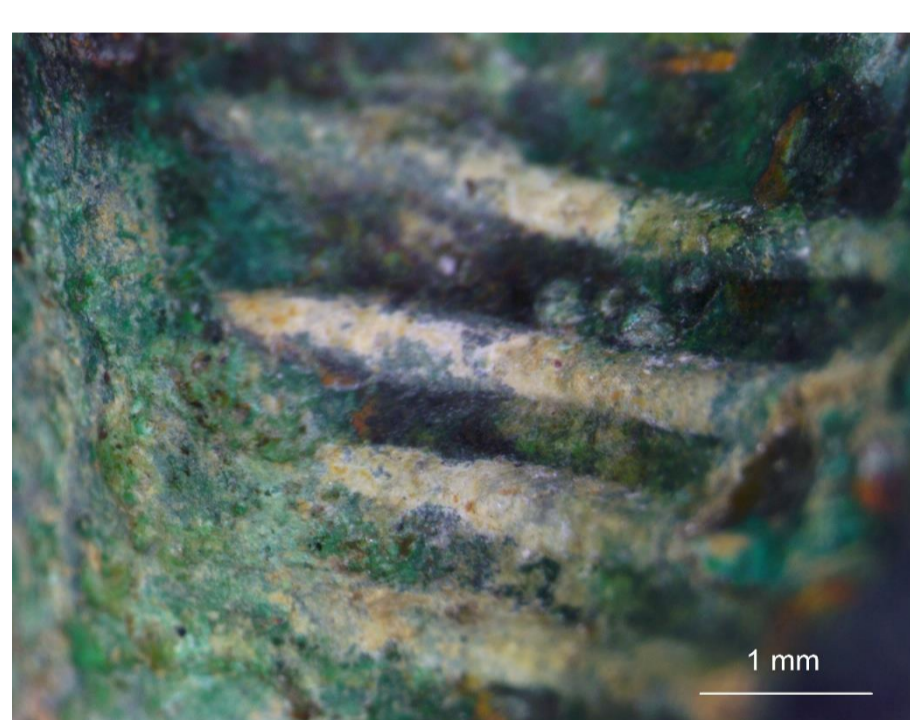
BSE image and spectrum of inv. 45 dec.



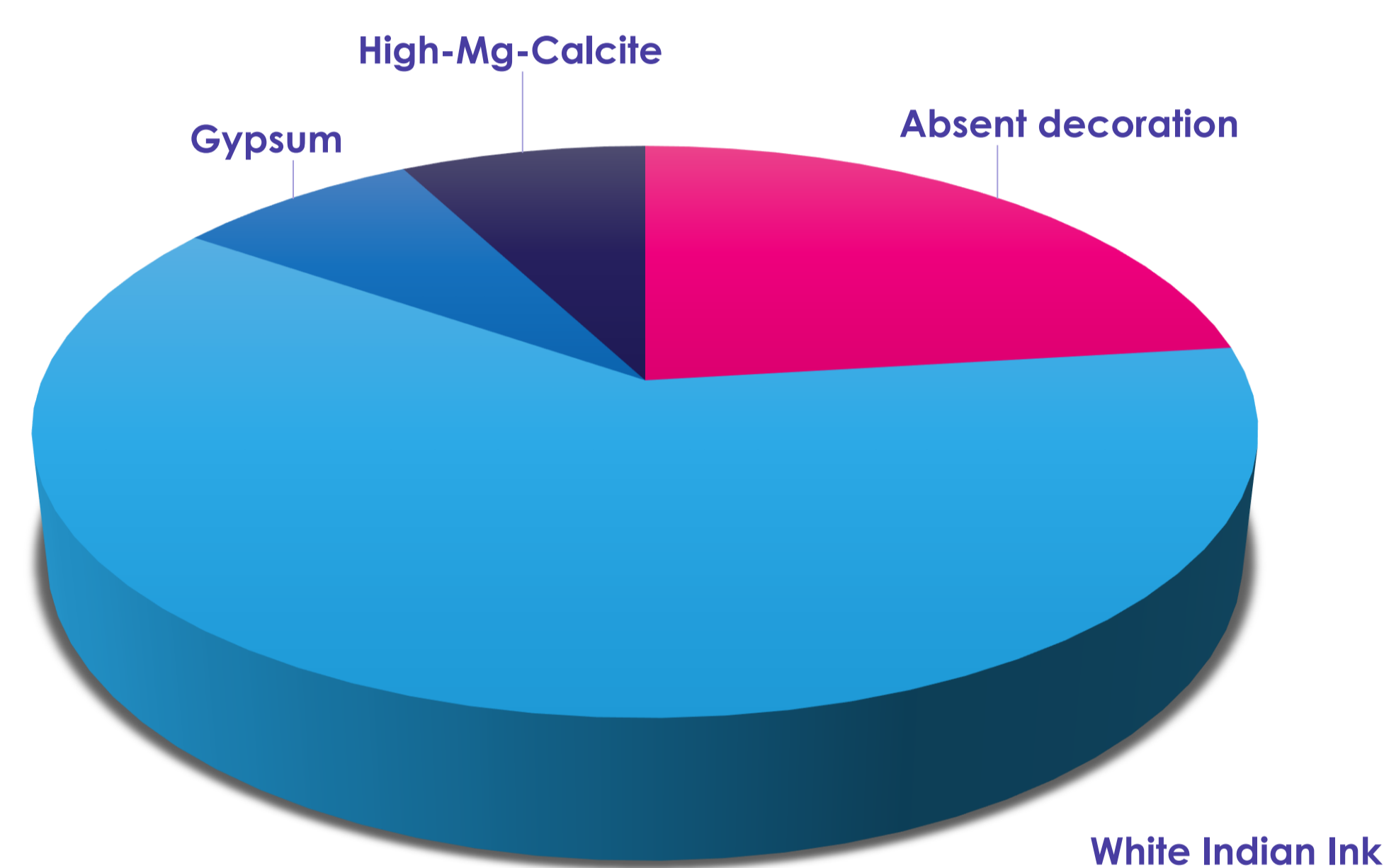
OM image of inv. 40 decoration (anatase).



OM image of inv. 128 decoration (gypsum).



OM image of inv. 3569 decoration (HMC).



Inv.	μ -Raman	μ -XRD	SEM-EDS	Interpr.
9	-	Bronze	Si, Al	No dec.
40	anatase	anatase, malachite, cuprite	Ti + Na, Mg, Al, Si, S, Cl, K, Ca, Fe, Cu, Sn	White Indian Ink
41	anatase, beeswax?	anatase, bronze, malachite	Ti + Mg, Al, Si, S, K, Ca, Fe, Cu, Sn	White Indian Ink
45	anatase	anatase, bronze, quartz	Ti (linear) + Na, Mg, Al, Si, P, S, Cl, K, Ca, Fe, Ni, Cu	White Indian Ink
46	anatase	cuprite, quartz	Ti + Mg, Al, Si, S, K, Ca, Cu	White Indian Ink
48	anatase	anatase, bronze	Ti + Na, Mg, Al, Si, S, Cl, K, Ca, F, Cu, Sn	White Indian Ink
49	anatase	anatase, bronze, quartz, malachite, azurite	Ti + Na, Mg, Al, Si, S, K, Ca, Cr, Fe, Cu	White Indian Ink
119	rutile	rutile, malachite, cuprite	Ti + Mg, Al, Si, P, S, Cl, K, Ca, Cu, Sn	White Indian Ink
128	gypsum + beeswax?	gypsum, bronze	Mg, Si, Al + P, S, Cl, K, Ca, Fe, Cu, Sn	Gypsum
3002	rutile	rutile, bronze, malachite, cuprite	Ti + Mg, Al, Si, P, S, Cl, K, Ca, Fe, Cu, Sn	White Indian Ink
3564	-	bronze, malachite, cuprite	Al, Si, Cu + Mg, P, S, Cl, K, Ca, Ti, Fe, Ni	No dec.
3565	-	quartz, tenorite	Cu, Si, Al + Mg, P, S, Cl, K, Ca, Fe, Ni	No dec.
3569	calcite	calcite, quartz, malachite, cuprite	HMC 16,20 %Mg (8,81-22,80%) Ca, Mg + Na, Al, Si, P, S, Cl, K, Ti, Fe, Ni, Cu	High magnesian calcite

Results & Discussion:

In eight fibulae, presence of titanium dioxide (TiO_2 ; related to the use of “white Indian” ink) was unequivocally acknowledged. This material accounts for a modern intervention, presumably carried out with the aim of highlighting these decorations aspect for a presumed public and scholarly use.

Different raw materials were instead identified in two cases – i.e., gypsum in inv. 128 (bright white) and high-magnesian calcite (HMC) in inv. 3569 (pale white). Presence of gypsum may be related to modern or ancient intervention, while the identification of HMC suggests the possible use in ancient time of different materials, such as white corals, minerals, fossil corals, or red coral denatured over time [3].

Conclusions:

Most of the analyzed fibulae (8 out of 13) unequivocally underwent a restoration intervention, as far as their whitish decorations are concerned.

In all specimens, the adopted approach allowed an exhaustive characterization of the raw materials used to produce these white decorations, checking their authenticity and chronological compatibility within the period in which these artefacts were manufactured.

[1] De Marinis R.C., *Il corallo nella cultura di Golasecca. Corallo Di Ieri Corallo Di Oggi* (2000), Edipuglia, Bari, pp. 159-175.

[2] Poggiani Keller R., Rondini P., *Bergamo and Parre during the Iron Age: Early Urbanization and the Alpine World., Crossing the Alps. Early urbanism between northern Italy and Central Europe* (2020), Sidestone press, pp. 275-298.

[3] Berruto G., Costa E., Curetti N., Diana E., Giustetto R., *Archaeometric investigation of bronze Iron Age fibulae with nested coral insets from three archaeological sites of the Piedmont region (Northwestern Italy)*, *Journal of Archaeological Science: Reports*, 51 (2023), 104119. <https://doi.org/10.1016/j.jasrep.2023.104119>