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# Residual strain mapping of Roman *styli* from *Iulia Concordia*, Italy

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ABSTRACT

*Iulia Concordia* is an important Roman settlement known for the production of iron objects and weapons during the Roman Empire. A huge number of well-preserved *styli* were found in the past century in the bed of an old channel. In order to shed light about the production processes used by Roman for *stylus* manufacturing, a neutron diffraction residual strain analysis was performed on the POLDI materials science diffractometer at the Paul Scherrer Institut in Switzerland. Here, we present results from our investigation conducted on 11 samples, allowing to define, in a non-invasive way, the residual strain map related to the ancient Roman working techniques.



## 1. Material and Methods

### 1.1. Archaeological Context and Investigation Project

*Iulia Concordia* is an important Roman settlement (presently *Concordia Sagittaria*, Venice, Italy) founded at the North-Eastern boundary of the Roman Empire. The settlement was located near the main Roman road that led to the *Noricum* region, prominent location for iron ore supplying.

Due to its geographical position, the city developed and assumed an important strategic role during barbaric invasions in 2nd–4th Century A.D.: *Iulia Concordia* was well-known to host important military forces and at least one workshop for weapon production (especially for the arrows: *sagittae*), although the exact location of the archaeometallurgical site is still undetermined. The metal working activities was related also to the production of everyday objects, as testified by the recovery of a huge number of *styli* in the bed of an old channel (Fig. 1) [1]. The findings are now part of the *Museo Nazionale Concordiese di Portogruaro* collection (Venice, Italy) [1–4]. A *stylus* is a small bar, made from either iron, bronze or bone, shaped with a sharp point and crowned by a *spatula* on the opposite end: it was used

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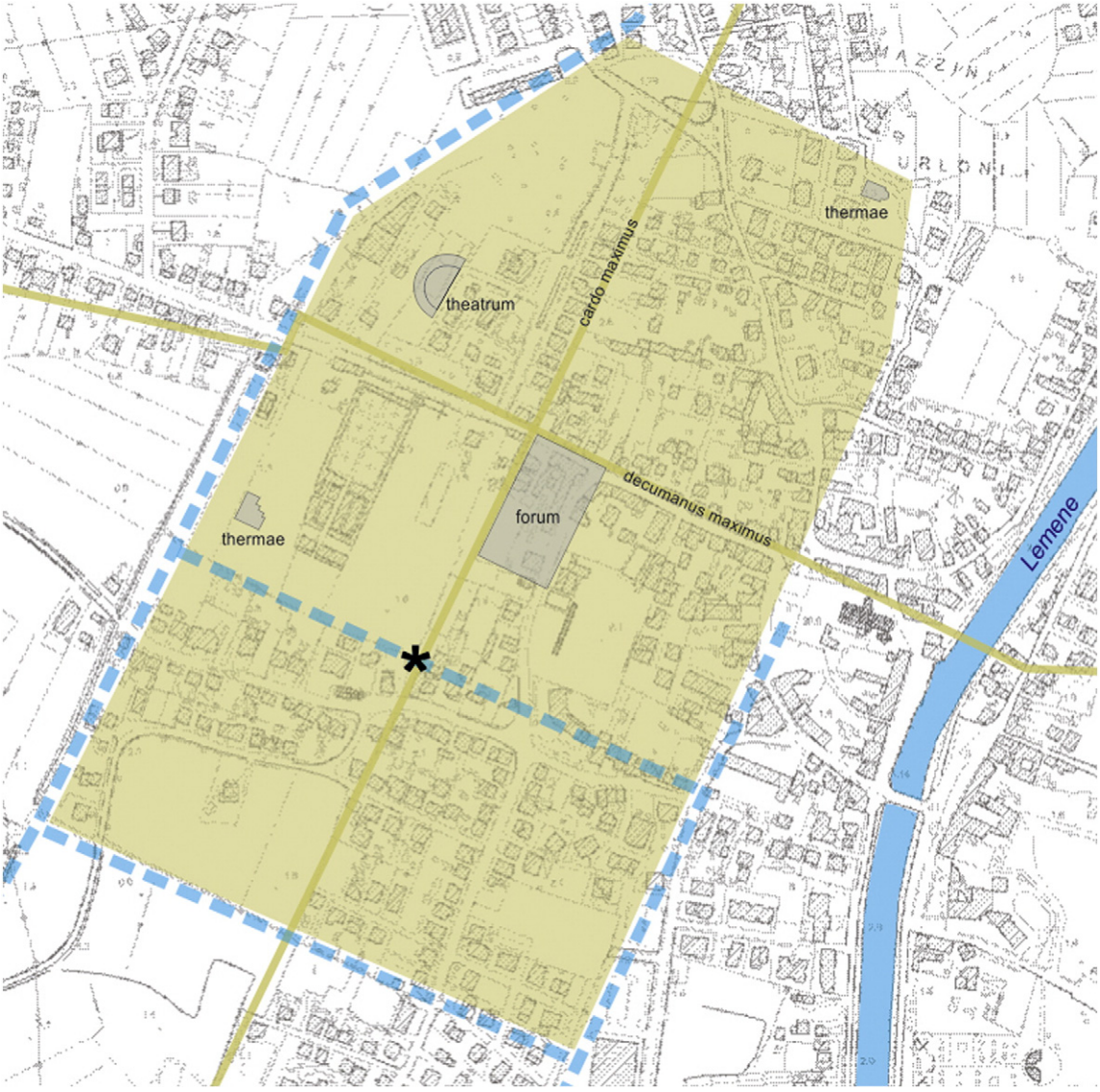


**Fig. 1 – Map of the Iulia Concordia site. Different layers show the historical urbanization levels of the area. The grey layer shows the current urbanization. The yellow area corresponds to the ancient Roman settlement with the main buildings filled in grey and the ancient channels in blue dashed lines. The black asterisk indicates the location where the 11 *styli* were found.**

for writing, with the pointed end, and for erasing any characters, with the opposite flat one, into the wax coated surface of wooden flat tablets. Even though few typological studies have been conducted, *styli* are characterized by several different shapes, hypothetically related to their age and provenance [5]. Furthermore there are no evidences of previous investigations about the production processes and the working techniques used by Romans for *stylus* manufacturing.

In order to investigate composition, assembly method, structural variations among different *stylus* typologies, and conservation *status*, an archaeometallurgical study project has been developed by the authors in cooperation with the *Soprintendenza dei Beni Archeologici del Veneto* (E. Pettenò, F. Rinaldi and V. Tinè).

Due to their small dimensions, *styli* are usually found strongly corroded; on the contrary, the findings from *Concordia* are exceptionally well preserved: thus, traditional (invasive) analytical methods cannot generally be applied, and, a non-invasive approach is mandatory. Neutron techniques, which are able to identify the morphology and the inner structure of artefacts have been applied in order to determine their manufacturing methods [6–10].

For the analysis presented in this work, we studied 11 examples of Roman *styli* from *Iulia Concordia* settlement, pertaining to different typological categories assigned through the stylistic analysis by archaeological experts (Fig. 2).

### 1.2. Scientific Approach and Investigations

Neutrons, thanks to their high power of penetration, represent an almost unique method for the non-invasive (NDT) characterization of the microstructure of massive metal