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The ancient steel sword and armour technology revealed through advanced neutron imaging techniques

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The metallurgy of historic arms and armours, is one of the most interesting topics in archaeometallurgy because these objects were manufactured, over the ages, using the highest quality materials and the most advanced technology [1-2]. In particular, the compositional and microstructural characterization of swords, particularly steel swords, can hence allow us to learn about the technological skill reached by different civilizations. The use of non-invasive techniques allows the study of museum objects in excellent conservation conditions thus giving a clear view of their characteristics, and neutron imaging is, to the authors' knowledge, one of the best methods to study morphology, identifying non-metallic inclusions, cracks and defects [3-6]. Thanks to the use of advanced techniques, such as energy selective imaging, the microstructural features and the distribution of the different phases in steel can be determined [7-10] so gaining important information about composition and manufacturing treatments (both thermal and mechanical). Following this path, we have performed a number of experiments using neutron imaging to reveal the characteristics of many artifacts, from different civilizations, of which the production procedures are not yet fully clear. We have studied the complex structure and the thermal and mechanical treatments applied to produce Japanese swords, the microstructure of wootz steel used to produce the "watered silk" pattern on Indo Persian swords, the multi-layered Fe-Ni alloys used to produce the Indonesian keris, composite renaissance swords from Solingen and Toledo, and pattern welded Viking swords. Concerning armours, we studied the method of making lamellar Japanese helmets and the microstructure of Indian armour pieces made of wootz steel. The results obtained non-invasively through neutron imaging allow us to identify unique features that can shed new light on the manufacturing methods thus increasing the level of our knowledge about the technological skill of such civilizations.

References

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