（General use）

MLF Experimental Report	Date of Report 03/10/2013
Project No. 2012B0088 Title of experiment Determination of the metallurgical microstructural properties of six ancient Japanese steel arrow tips through wavelength resolved neutron transmission analysis Name of principal investigator Francesco GRAZZI Affiliation Consiglio Nazionale delle Ricerche ITALY	Name of person responsible for instrument Kenichi Oikawa Name of Instrument/（BL No.） BL10 Date of Experiment 24–29 January 2013

Please report your samples, experimental method and results, discussion and conclusions. Please add figures and tables for better explanation.

1. Name of sample(s) and chemical formula, or compositions including physical form.

Japanese historical arrow tips (n. 4), made of carbon steel with different amount of carbon weight %

2. Experimental method and results. If you failed to conduct experiment as planned, please describe reasons.

We have analyzed the 4 Japanese arrow tips attributed to the Edo period (17^{th}-19^{th} century) with different shape, composition and conservation status. The sample composition was previously determined through ToF-ND.

The position sensitive wavelength resolved neutron transmission analysis (PS-WRNTA) technique was used to perform the experiment exploiting the time of flight feature to determine the microstructural properties of the samples as microstrain, phase distribution and degree of crystallinity. An innovative high spatial, high time resolution detector, developed by A. Tremsin, was used to obtain, at the same time, a whole set of radiographies, each for a specific neutron wavelength.

2. Experimental method and results (continued)

The detector was set to scan regions corresponding to the main Bragg edges in the transmission spectrum of ferrite (the main phase of each sample), namely the 110 (4.05 Å), 200 (2.68 Å), and 211 (2.34 Å) reflections. The data were normalized using the open beam images.

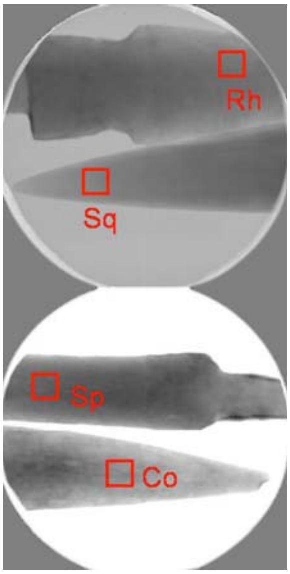

Figure 1. Energy integrated radiography of the samples. The microstructural features are revealed by the different levels of gray. The red squares define the areas of the wavelength distribution intensity (fig. 3).

In this way it was possible to map the Bragg edge features through the whole volume of the samples (see fig.s 1 and 2).

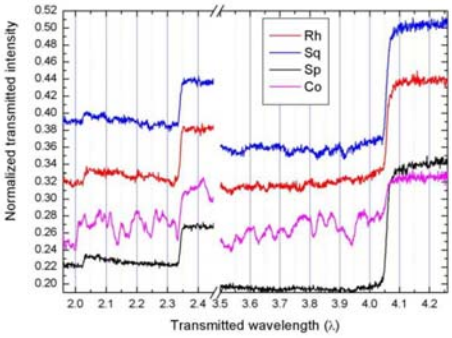

Figure 2. Wavelength distribution intensity of the highlighted areas of fig. 1 corresponding to the 211 and 110 Bragg edges. The cone sample (pink) presents several ferrite single crystal oriented grains, identified by the presence of dips in the left side with respect to the edge. Minor presence of oriented single crystals is present in rhomb (red) and square (blue) samples while the spear one (black) appears to be isotropic.

Identification and mapping the presence and orientation of single crystals in iron, represents an outstanding result in the study of ancient and modern metallurgy.