Contribution ID: **1** Type: **ORAL**

Neutron techniques employed to study objects from the Wallace Collection

Monday 13 June 2022 11:40 (20 minutes)

As well as being a picture gallery, this museum holds the largest collection of European armour in London, and one of the best collections of Indo-Persian swords and armour outside the subcontinent.
While it is possible to analyse plate armour by microscopic examination of a cut edge, or a fragment detached from a hidden interior damaged surface, such as a sample from the helmet of King Henry V. Such examination is not possible with
swords, unless they are already broken, which rules out museum objects, although archaeological specimens may be available. So we have for some years been using neutron techniques to study swords and helmets from this museum, as well as from Canterbury Cathedral, at ISIS the neutron source in the Rutherford-Appleton Laboratory, Harwell, and other neutron sources. Neutron diffraction can tell us the carbon content of the steel, the phases present, and whether any heat treatment to harden the steel has been carried out.
We have examined a number of swords and daggers from the Oriental collection by neutron diffraction (since 2015 up to now 75). Many Oriental blades were made from crucible steel, a hypereutectoid cast steel, and a proportion of those were forged in such a way as to retain a distinctive surface pattern (the so-called "Damascus steel"). The high value of this steel led to many attempts to simulate its presence by etching, by differential welding, and even by welding thin layers of such a steel onto an iron body. Neutron diffraction can tell us the quantity of iron carbides present, any anisotropy in their distribution (viz. whether there is a pattern below the surface that has been hidden by overzealous 19th century polishing) and, possibly, even information about its thermal history.
Phase-contrast neutron imaging, developed at the Helmholz Zentrum, Berlin, has proven to be an invaluable technique for rendering partly obliterated armourers'marks visible again. If these marks were struck cold, then the strained metal will
change the path of neutrons, and be detectable, even when covered over by later polishing. On the other hand, marks struck before the final heat-treatment and assembly, will not show any signs of microstrain. While revisualization of such marks will then be disappointing, new unexpected insights into workshop practice may arise.

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Session Classification: Opening session

Track Classification: Track 1: Application of accelerator science and technology