Chemical Mapping and Carbon Speciation Analysis of Ancient Materials with X-ray Spectroscopy

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The *Syriac Galen Palimpsest* contains a Syriac (an Aramaic dialect) translation of the writings '*On Simple Drugs*' by the Roman and Greek physician, surgeon, and philosopher, Galen of Pergamon, considered to be one of the most accomplished of all medical researchers of antiquity. Scholars are interested in these writings as they represent the largest piece of Galen's work in Syriac, opening a new perspective on the reception and appropriation of the Greek medicine in the Semitic cultural traditions. We employed a combination of synchrotron rapid-scan XRF imaging and machine learning to uncover large sections of these writings to be seen for the first time in modern times.

We will also present our planned XRF imaging experiments of the *Codex Climaci Rescriptus* (*CCR*). *CCR* is a collective palimpsest manuscript thought to contain writings of the Greek astronomer, geographer, and mathematician Hipparchus of Nicaea. Hipparchus is viewed as the greatest ancient astronomical observer, and his *Star Catalogue* has often been considered his magnum opus, although it was only known from indirect references. It aimed at providing precise coordinates of all stars visible to the naked eye, marking around 850 stars. In 2022, multispectral imaging of *CCR* revealed fragments of Hipparchus's original *Star Catalogue* [1], yet large sections are yet to be uncovered. Our team has identified 12 folios/bifolios as most critical to the understanding of the *Star Catalogue* and other writings. Synchrotron rapid-scan XRF imaging experiments of these leaves are planned to start in January at SSRL.

We will conclude by discussing our ongoing work using X-ray Raman scattering (XRS), a technique that overcomes some of the limitations of conventional soft X-ray absorption spectroscopy when probing light elements in bulk materials. XRS-based carbon K-edge XANES can be employed to disentangle the carbon chemistry of Australian plant exudates from a unique historical collection. These extraordinary plant materials have been used for millennia for various applications and are still employed in contemporary art.

[1] Gysembergh, V; Williams, PJ; Zingg, E; **New Evidence for Hipparchus' Star Catalogue Revealed by Multispectral Imaging**, *Journal for the History of Astronomy* **53**, 383-393 (2022).

Kristen St. John, Michelle Corneliuson Smith, and David Brock from the Stanford Libraries are about to disbind the *Syriac Galen Palimsest* for XRF imaging at SSRL.