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Novel microfluidic devices for investigating microscale trends in flow and geochemistry *in-situ* using X-ray fluorescence microprobe spectroscopy

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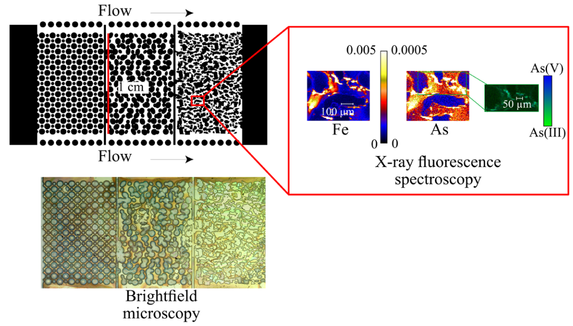

Microfluidic devices are increasingly popular within the Earth sciences as experimental flow systems that replicate natural rock and soil structure while providing a direct window into coupled flow, biological, and geochemical processes occurring within these rocks and soils at the microscale. These devices have been used to examine microscale trends in a range of soil and rock relevant systems from multiphase flow to microbial reduction of uranium [1], [2]. X-ray fluorescence microprobe spectroscopy (XRF) makes a natural pairing with these systems since they have sufficient resolution to resolve microscale trends in chemistry and have the unique capacity to directly image spatiotemporal trends in flow and geochemistry. However, most studies using XRF microprobes with microfluidic chips have been unable to map geochemistry *in-situ*, as common microfluidic chip designs use materials that strongly attenuate the x-rays needed to investigate common earth elements. In this work, we present the methods for fabricating silicon based microfluidic chips which overcome this limitation with a thin glass window [3]. The capabilities of this device are shown by presenting results from in-situ XRF mapping, µXANES, and multiple energy mapping performed at NSLS II Beamline 4-BM to examine the evolution of As(III) and As(V) sorbed to an Fe (hydr)oxide precipitate. Finally, we will discuss experimental considerations for using microfluidic chips in combination with XRF, as well as discuss alternative processes for fabricating microfluidic chips that are compatible *in-situ* XRF microprobe analysis. The combination of XRF microprobes and microfluidic chips represents a powerful combination of techniques that can be used to probe microscale flow and biogeochemical phenomena.

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[2] Zhao, MacMinn, & Juanes (2016) *Proc. Natl. Acad. Sci.* pp. 201603387–201603387, 2016, doi: 10.1073/pnas.1603387113.

[3] Chen & Kocar (2021) *J. Synchrotron Radiat.*, vol. 28, no. 2, pp. 461–471, doi: 10.1107/S1600577520016239.