High-resolution 3D and (sub-)cellular level LA-ICP-MS imaging approaches: accumulation of toxic metals in biological material

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Novel approaches for elemental mapping via LA-ICP-MS have emerged in cellomics, metallomics and proteomics, induced by the progress achieved in the development of low-dispersion setups characterized by improved detection limits and sample throughput. These approaches include the mapping of the trace-level nuclide distribution within structures $< 10^4\ \mu m^3$ in volume, using a laser beam waist size of $1 - 3\ \mu m\ \emptyset$, and rapid 3D imaging. This work demonstrates both approaches in selected applications related to metallotoxicity. In a first study, a photosynthetic dinoflagellate (*Scrippsiella trochoidea*), was exposed to Cu concentrations at 12 different levels, ranging from 0.5 to 100 µg/L, and treated with a critical point drying protocol. ~100 cells of each population were individually ablated using a single-point ablation protocol, permitting the Cu distribution in the entire population across different exposure levels to be evaluated. LA-ICP-MS imaging ($2 \times 2\ \mu m^2$ beam size) of the Cu distribution in individual cells was cross-validated with *in vivo* optical tweezers-based synchotron radiation confocal X-ray fluorescence (XRF) imaging. In a second study, the 3D distribution of heavy metals in wheat (*Triticum dicoccum*, *Triticum aestivum*) and rye (*Secale cereale L.*) grains at typical exposure levels was visualized ($20 \times 20\ \mu m^2$ beam size) and quantified. Grains embedded in an epoxy block were analyzed *via* serial sectioning, followed by image registration for volume reconstruction. Calibration was performed *via* standard addition using a set of spiked matrix-matched pellets.

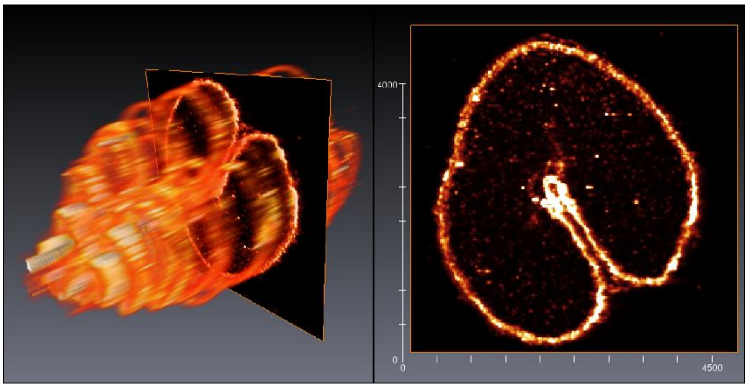

Figure 1(left) 3D reconstruction of Secale cereale L. Mn distribution at typical exposure levels. (right) Single cross-section of the 3D volume.