☒ **Talk** ☒ **Poster**

Combining synchrotron spectromicroscopy with NanoSIMS to reveal the formation of soil organo-mineral associations

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Soil organic carbon (SOC) stabilization is a key process regulating terrestrial C storage, yet the fine-scale mechanisms that govern how C inputs are transformed and subsequently associate with mineral remain poorly understood. Using spectromicroscopy techniques at the Canadian Light Source synchrotron, coupled with NanoSIMS analysis of stable isotope tracers at the Technical University of Munich, we investigated how minerals and other abiotic conditions modulate the formation, composition, and spatial distribution of organo-mineral associations in the soil, studying both plant litter and root exudates as C inputs.

In one study [1], we added ^{44}Ca to soils amended with $^{13}C^{15}N$-labeled litter and found that Ca promoted the microbial transformation of litter into mineral-associated organic matter (MAOM). Fourier-transform infrared (FTIR) spectromicroscopy showed that Ca addition enhanced the co-localization of microbial-derived aromatic and carboxylic C with clay minerals, while NanoSIMS analyses provided evidence that Ca was co-localized with ^{15}N-enriched microbial products at mineral surfaces, emphasizing Ca's role as a biotic and abiotic mediator of SOC stabilization.

In a second study [2], we pulse-labeled maize plants with $^{13}CO_2$ to examine how organo-mineral associations form with root exudate C. Exudates formed organo-mineral associations in the clay fraction and disrupted existing associations in silt fraction, with clay particles in the rhizosphere showing greater chemical and spatial heterogeneity than in the bulk soil. STXM-NEXAFS and NanoSIMS revealed that Ca was strongly correlated with C in the rhizosphere, supporting its role in exudate stabilization. NanoSIMS images indicated that ^{13}C from exudates was spatially co-localized with microbial bio- or necromass, suggesting that microbial uptake of root exudates is an important step in their associations with minerals.

These findings highlight the utility of synchrotron-based techniques, in combination with NanoSIMS, for resolving organo–mineral associations and reveal new insights into the roles of abiotic and biotic factors in shaping SOC fate.

References

[1] Shabtai, I.A., Wilhelm, R.C., Schweizer, S.A. *et al.* Calcium promotes persistent soil organic matter by altering microbial transformation of plant litter. *Nat Commun* **14**, 6609 (2023).

[2] Shabtai, I.A., Hafner, B.D., Schweizer, S.A. *et al.* Root exudates simultaneously form and disrupt soil organo-mineral associations. *Commun Earth Environ* **5**, 699 (2024). https://doi.org/10.1038/s43247-024-01879-6