Gaining new perspective on the nano- and microscale:
Combining elemental mass spectrometry and optical methods to characterise single particles

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Nano- and microparticles are increasingly produced and emitted into the environment. Unfortunately, we continue to face difficulties to study their behaviour which are dependent on size, molecular and atomic composition as well as on number concentrations. This is anchored in the elusive nature of small particles and the requirement for very different analytical strategies to retrieve comprehensive and coherent information on a single particle level. As such, we fail to understand basic traits and their implications for human and environmental health.

The development and maturation of single particle inductively coupled plasma – mass spectrometry (SP ICP-MS) set a paradigm shift for the tracing and characterisation of particles. However, the pure "elemental" perspective provided through SP ICP-MS also obscures our vision at the nano-scale and we are blind for a considerable number of particles as well as properties.

This presentation will showcase new strategies to enable a comprehensive molecular and elemental characterisation of single particles (SP). Through the on-line coupling of two-dimensional optical traps, SP Raman spectroscopy and SP ICP-TOFMS, it becomes possible to carry out non-target screenings, to decipher the molecular and elemental composition of individual entities as well as to determine number concentrations and size distributions. The presentation will detail the underlying considerations and strategies and focus on new instrumentation, its hyphenation and future potential.

Literature:

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- T. E. Lockwood , R. Gonzalez de Vega, Z. Du, L. Schlatt, X. Xu, **D. Clases**, "*Strategies to enhance figures of merit in ICP-ToF-MS*", J. Anal. At. Spectrom. (**2024**), 39, 227-234 (10.1039/D3JA00288H)
- R. Gonzalez de Vega, T. E. Lockwood, L. Paton, L. Schlatt, **D. Clases**, "*Non-target analysis and characterisation of nanoparticles in spirits via single particle ICP-TOF-MS*", J. Anal. At. Spectrom. (**2023**), 38, 2656-2663, (10.1039/D3JA00253E)

Metal stable isotopes in the marine realm

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Understanding the biogeochemical cycling of transition metals is important, because these elements are essential micronutrients, yet also often toxic at higher concentrations. Metal stable isotope measurements are a powerful tool to trace the sources and/or processes that control their distribution in the natural environment. The field of marine metal stable isotope geochemistry originated in the late 1990s, and has expanded dramatically over the last decade. Here, we briefly review the marine stable isotope cycling of several transition metals. Isotopic variability internal to the ocean is driven by a range of biogeochemical processes and their interaction with the physical ocean circulation. Mean whole ocean isotopic compositions are controlled by the isotopic composition of oceanic sources and fractionation into sedimentary sinks. The isotopic oceanic mass balance of each metal is reviewed, providing revised oceanic residence times estimates.

High-precision analysis of non-traditional isotopes in environmental research

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The use of stable isotope ratios in the studies about elemental biogeochemical cycling and sourcing of materials (e.g. food, pollutants, historical remains, and artefacts) has undergone a transformative shift with the integration of non-traditional elements. While conventional light stable isotopes (C, H, O, N) have been pivotal in elucidating environmental processes, recent advancements extend the isotopic toolkit to include, for example, isotopes of strontium, lead, cadmium, and chromium and now play an essential role as tracers in Earth and environmental sciences. In parallel, advances in mass spectrometric instrumentation have markedly improved sensitivity and precision, facilitating the reliable detection of even the slightest fluctuations in the isotopic composition of elements with more than one natural isotope. However, despite these advancements, significant analytical challenges persist due to the diverse range of analyte/matrix combinations, concurrent matrix effects, spectral interferences, instrumental isotopic fractionation, and the lack of certified reference materials. The presentation will emphasize the versatility of non-traditional isotopes, highlighting their role in refining precision, expanding analytical capabilities, and deepening our understanding of interconnected systems. Furthermore, it will address the challenges of method development for accurate isotope ratio determination and the capabilities and limitations of various mass spectrometers.

The occurrence and drawbacks of two-phase aerosol transport upon ablation of soft biological matrices using nanosecond laser ablation-inductively coupled plasma-mass spectrometry.

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Abstract to follow.