Why less is more – high-time resolution from laser-ablation mass spectrometry in palaeo-environmental research and beyond

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Laser-ablation systems coupled to inductively-coupled-plasma mass spectrometers (LA-(MC-)ICPMS) have - after pioneering work in the late 1980s and 1990s – matured through the 2000s and have now arguably become the key microanalytical technique with wide-ranging applications. The success of LA-(MC-)ICPMS is due to the combination of sub-ppb detection limits, (highest precision) isotope capability, limited matrix dependency, relatively simple mass spectra owing to the high-temperature ICP-excitation source, limited sample preparation with no vacuum requirements and overall low capital cost. On the other hand, Secondary Ion Mass Spectrometry (SIMS) remains the method of choice for spatially-resolved isotope ratio analysis of the light stable elements (chiefly O, C).

High spatial resolution analysis of fast growing environmental archives such as molluscs, speleothems, corals, teeth, ice cores etc. translates into very high achievable time resolution of various chemical or isotopic proxies, such that even daily resolution in geological 'deep-time' (i.e. pre-Pleistocene) is now attainable. This enables an evaluation of the role of (sub-)seasonal shifts in climate transitions or palaeoecology. To be applicable, (palaeoceanic) proxies however require calibration through culturing experiments under controlled environmental conditions. Here again spatially-resolved analysis simplifies culturing via much shortened periods because even small growth segments can be analyzed and identified easily, especially if labelled in isotopically-enriched (e.g. ^{135}Ba) seawater.

Even though ice cores may not appear as the obvious target of LA-ICPMS analysis, if (sub-)annual resolution of dust compositions as proxy of atmospheric circulation is desired, cryo-cell-UV-LA as pioneered at RHUL facilitates ~monthly resolution even in deep ice cores. This reveals the rapid and sustained shift in dust provenance within less than one year at natural abrupt climate change events.

This presentation will showcase some of these applications on foraminifera, molluscs, teeth and ice cores and will conclude with an outlook towards outstanding issues for LA-MC-ICPMS.