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Who needs chemistry when you have lasers and a tandem accelerator?

ROBIN GOLSER[1], OSCAR MARCHHART[1], MARTIN MARTSCHINI[1], MARCO MICHEL[2], ERIK STRUB[2], ALEXANDER WIESER[1] AND **SILKE MERCHEL**[1]

[1]University of Vienna, Faculty of Physics, Isotope Physics
[2]University of Cologne, Division of Nuclear Chemistry

Presenting Author: silke.merchel@univie.ac.at

For many years, cosmogenic nuclides such as ^{10}Be, ^{14}C, ^{26}Al and ^{36}Cl are routinely determined by accelerator mass spectrometry (AMS) to quantify and date processes in Earth, Environmental and Planetary Sciences. More recently, AMS was successfully performed to measure long-lived radionuclides of (mainly) anthropogenic sources, such as ^{41}Ca, ^{55}Fe, ^{90}Sr, ^{99}Tc, ^{129}I, $^{135/137}$Cs, $^{233/236}$U, and ^{237}Np. Analytically most challenging are radionuclides (^{60}Fe, ^{182}Hf, ^{244}Pu) with isotopic abundances as low as 10^{-16}. Those nuclides are the remains from nuclear stellar processes and had been stored in terrestrial archives such as marine deep-sea sediments.

Applications are very diverse: Starting from cosmochemistry to reconstruct irradiation conditions of meteorites and the constancy of the cosmic radiation itself over geomorphology and oceanography to study climate and environmental changes to finally nuclear decommissioning and waste storage.

Common to all, however, is the tedious radiochemical separation to deplete matrices and isobars, which was usually a prerequisite for AMS hindering fast and reasonable analysis until recently. Now, the world-wide unique ion-laser interaction mass spectrometry (ILIAMS) system developed at the Vienna Environmental Research Accelerator (VERA)[1] provides isobar suppression by up to fourteen orders of magnitude.

Hence, ILIAMS-assisted AMS enables the direct detection of e.g., ^{26}Al/^{27}Al (~10^{-10}) and ^{41}Ca/^{40}Ca (~10^{-11}) in simply-crushed stony meteorites containing intrinsic ~1% Al and Ca. The presence of isobars, natively-abundant elements (15% Mg, 0.1% K), does not cause any analysis problem, making any radiochemical separation redundant.

We have also quantified ^{41}Ca/^{40}Ca as low as 10^{-12} – in the presence of 0.5% potassium – without any chemical treatment for concrete and simple HCl leaching for heavy concrete (baryte); both materials were earlier exposed to thermal neutrons in a nuclear reactor.

Additionally, first ^{26}Al/^{27}Al (~10^{-11}) tests on terrestrial quartz samples from high altitudes used for surface exposure dating look promising to set-up AMS as a pre-screening and sample selection method before starting tedious chemistry for more accurate results. When combined with a high-ion current output ion source, high-accuracy results without any chemistry might be within reach.

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[1] Martschini et al., 2022, doi.org/10.1017/RDC.2021.73.