Laser Ablation – Accelerator Mass Spectrometry: rapid and spatially resolved radiocarbon analyses of carbonate archives

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Spatially resolved radiocarbon ($^{14}$C) profiles in carbonate archives (e.g. corals, speleothems, shells) are difficult to accomplish due to tedious multi-step sample preparation required for conventional $^{14}$C measurements, employing accelerator mass spectrometry (AMS). Furthermore, producing a highly resolved $^{14}$C record implies processing a large number of subsamples, which is very time consuming.

A novel setup [1, 2, 3] has been developed at ETH Zurich that combines high spatial resolution of laser ablation (LA) with the sensitivity of AMS, enabling rapid in-situ determination of $^{14}$C in carbonate samples. An ArF-excimer laser beam ($\lambda = 193$ nm) is focused on the carbonate sample, generating CO$_2$ that is directly introduced into the AMS gas ion source. Pressed carbonate powder reference materials (IAEA C2, CSTD, in-house standards) and marble have been used to investigate the analytical behavior of the new LA-AMS system including sensitivity, accuracy, background and cross-contamination. Best measurement conditions were reached using a carbon flow into the ion source of about 3 $\mu$g/min, resulting in negative ion currents up to 20 $\mu$A, a detection limit of about 1% of the modern $^{14}$C concentration, and a reproducibility of reference materials within counting statistics. Different sampling strategies are compared using a stalagmite sample comprising the $^{14}$C bomb pulse. The applicability of the setup for other materials such as corals and shells is demonstrated.

The continuous sampling of the LA-AMS setup offers great flexibility with regard to analysis time, spatial resolution and measurement precision: several cm per hour can be scanned, providing rapid overview screening of the $^{14}$C abundance in a sample. A resolution of 100 $\mu$m and measurement precision of 1% is achievable for modern samples. A detailed overview of the todays’ performance of the setup will be given and implications on new possible applications will be reviewed.