Peering into the Past: Onsite Archaeology with a Portable QMS

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Portable mass spectrometers (MS) are finding increasing application for on-site analysis and measurement. Quadrupole mass spectrometers (QMS) are well-suited to portability and reported limits of detection are now at sub-ppb levels. ^{13}C stable isotope analysis is usually conducted on benchtop, magnetic sector instruments, but portable on-site QMS measurement would have applications in environmental monitoring and in archaeology and paleobiology. The ability to measure $\delta^{13}C$ levels with a portable QMS would enable archaeologists to streamline the iterative process of collecting, analysing and interpreting measurements on-site without the need for time consuming laboratory analyses off site.

A portable QMS prototype system was constructed around a filter with hyperbolic-profile electrodes to optimise resolution and sensitivity, By exploiting the most convenient isotopologue configuration for $^{13}CO_2$, the instrument was used to test the ability to measure $^{13}C/^{12}C$ ratios in two analytes: CO_2 gas from a small pressurised cylinder and evolved CO_2 from the bioapatite fraction of medieval bone samples. $^{15}N/^{14}N$ ratios in ambient N_2 were also measured. Precision of the results was compared with that of typical commercial $\delta^{13}C$ measurements, as a demonstration of applicability to ancient bone.

Measurements have demonstrated feasibility of measuring evolved CO_2 and of determining $\delta^{13}C$ on-site from bone samples. Ion source modification is underway to further enhance performance with the aim to achieve 'flat top' mass spectral peaks obtainable on magnetic sector instrumentation. Theoretically this, and improved sampling protocols, should reduce the absolute instrumental and experimental error for $\delta^{13}C$ measurement, with the aim being to bring the total error to the <0.1‰ tolerances required for high-quality archaeological sample analyses. However, even without modifications to the ion source, the current instrumentation shows the capability for approximate $\delta^{13}C$ determinations in the field avoiding time consuming off site analysis. On-site ^{14}C measurement for age determination is also being investigated and the prospects for this with portable instrumentation will be discussed.