Nanoscale quantification of isotope ratios by atom probe tomography

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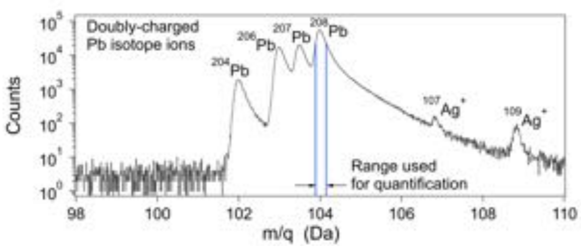
A number of recent studies have employed atom probe tomography (APT) to quantify isotopic ratios at sub-micron length scales. These have led to new insights into isotopic geochronmeters such as U-Pb in zircon, and the ability to date intermediate events [1-3]. The precision of small-scale isotopic measurement is fundamentally limited by the number of atoms available in the nano-scale region of interest, so precise quantification relies upon a local concentration of the relevant isotopes, and a high detection efficiency in the method used. A significant advantage of APT, is the near-100% ionisation and capture of all atoms by the mass spectrometer, regardless of atomic number. Total detection efficiency may be as high as 80% from the region of interest, and uniform across all elements, yielding a large number of counts from a sub-micron region.



In this study, several analyses were performed on samples well-characterised by SIMS and TIMS to determine the accuracy of isoptope ratio measurements derived from APT data. In particular, Pb isotope ratios were compared betweeen APT and conventional methods using a galena Pb-isotope standard. Challenges to accurate quantification include mass-peak shape variability, and overlapping mass-peak tails (see figure). We discuss the characterisation of potential isotopic fractionation effects and the extent to which APT may be relied upon for quantitative isotopic ratios.

[1] J.W. Valley et al., (2014), Nat. Geosci. 7, 219-223. [2] E.M.Peterman et al., (2016), Sci. Adv. 2, e1601318. [3] L.F. White et al., (2017), Nat. Comms. 8, 15597.