Towards estimating the complete uncertainty budget of quantified results measured by LA-ICP-MS

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Interpretation of LA-ICP-MS measurements is improved if the analyst is presented with a comprehensive uncertainty budget. As well as enabling judicious application of the results, an uncertainty budget rapidly guides the analyst in method optimisation and appraisal of external constraints.

The first attempt at estimating the total uncertainty budget for the quantification of trace elements by LA-ICP-MS was published by Luo et al. [1] with their calculation based on the EURACHEM/CITAC-Guide [2]. We have implemented that approach in a new software package LADR (pronounced "ladder') that can load data files from most commercially available ICP-MS instruments.

The uncertainty calculation was validated using a stochastic model to produce synthetic data sets for processing. Assessment of measurements from a range of real samples was based on community guidelines [3] and complementary studies [4].

A significant benefit of determining and quantifying all of the factors contributing to the complete uncertainty is the ability to purposefully resolve parts of the budget relating to precision and accuracy components. To facilitate the interpretation of measurement uncertainty, here we introduce the concept of *levels* of uncertainty as a useful practical tool to assist the analyst. The levels we define are descriptively named "Signal Error", "Signal & Background-Noise Error", "Within-Run Analytical Precision", "Full Within-Lab Analytical Precision", and "Full Analytical Uncertainty". The software allows the analyst to choose to report uncertainty values appropriate to a specific intra-run, intra-laboratory, or inter-laboratory comparison.

The software package "LADR" is available for download from the authors' website [5].

[1] Luo et al. (2007) JAAS **22.2**, 122-130. [2] Ellison & Williams (2012) Eurachem/CITAC guide, ISBN 978-0-948926-30-3. [3] Horstwood et al. (2016) *Geostand. Geoanalytical Res.* **40.3**, 311-332. [4] Gilbert et al. (2013) *Geostand. Geoanalytical Res.* **37.1**, 51-64. [5] http://norris.org.au/ladr/ "LADR" (Mar 2018).