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Evaluation of changing relative contributions of various uncertainty sources in initial isotopic ratio calculations

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In order to be meaningfully compared, radiogenic isotopic ratios for old samples must be corrected for daughter isotope ingrowth – but unfortunately most studies do not scrutinize the additional uncertainties accumulated during this calculation. Reducing total uncertainty in calculated initial isotopic ratios requires assessment of the relative contributions of errors associated with each input. We present easy-to-use tools in Microsoft Excel, DataGraph (MacOS) and R that do just that: (1) propagate uncertainties in parent and daughter elemental concentrations, measured isotopic ratios, age, and decay constants and (2) compare their roles during age-correction for Rb–Sr, Sm–Nd, Lu–Hf and U,Th–Pb isotopic systems. The calculations can be applied to natural datasets or used interactively to visualize consequences of changing values of variables and their associated errors. Generally speaking, the main drivers of total uncertainty are geologic age and parent/daughter (P/D) ratio – but for young samples (and small total amounts of ingrowth) these are negligible. The interactive tools are useful for modeling less-intuitive scenarios where, for example, large errors in age determination may be compensated for by precisely determined P/D or vice versa. In general, as one (or more) of these major contributor(s) to overall uncertainty begin(s) to dominate the summation in quadrature, the other fixed sources of error (i.e. uncertainty in isotopic ratio and decay constant) are suppressed to the point of being insignificant. The points in multicomponent age–σ_{age}–P/D–$\sigma_{P/D}$ space where this occurs are different for each isotopic system – as are the boundaries of regions where uncertainties in age vs. elemental concentrations dominate. For the example of Rb–Sr data from a Variscan (340 Ma) sample, an acceptable uncertainty of ± 0.0001 in $^{87}Sr/^{86}Sr_i$ can be achieved using ICPMS concentration data (typically 2–3% relative errors on both Rb and Sr) if the Rb/Sr ratio is 0.15 or less (Fig.1). If the error in age and/or the Rb/Sr is higher, the requisite precision can only be achieved through isotope dilution (Fig.2).