

How Much is Your Resource Worth? Geochemical Sampling Error Revisited

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Whole-rock geochemical data underpin resource estimation, deposit characterization, and processing decisions, yet the relationship between sample mass, mineral grain size, and analytical precision is difficult to explicitly quantify. This issue depends critically on our understanding of geochemical sampling error — the compositional difference between a collected sample and the rock body it represents. Sampling error is a fundamental but underappreciated source of uncertainty in modern geochemistry, as most workers focus on analytical precision and accuracy while ignoring the difficult-to-determine sampling error. There is a long and rich history of geochemical sampling error estimation, with both theoretical and empirical solutions offered to the exploration community. We build on this work by presenting an empirically calibrated sampling error estimation model with substantial improvements over previous approaches.

We draw on previously published theoretical frameworks and an empirical test using a coarse-grained K-feldspar megacrystic granite. Inconsistencies between previous models and our empirical data led us to introduce a modified theoretical approach incorporating the closure effect — the mathematical requirement that mineral modal proportions and elemental concentrations sum to 100%. This modified approach produces sampling error estimates that better match observations. Sampling errors for abundant elements like Si and Al are dampened relative to theoretical predictions, while errors for elements hosted in accessory or minor phases are amplified. These patterns have direct implications for how geochemists and exploration geologists interpret variability in drill core and outcrop suites, ultimately affecting resource estimation.

We package our new Monte Carlo model, SAMPLERR, into a web application that allows users to estimate sampling uncertainty for any rock type given mineral modes, grain sizes, and target sample masses. Practical guidance on minimum sample masses for common ore deposit types is discussed, with emphasis on how inadequate sampling can bias datasets in ways that are difficult to detect after the fact.