Re-Os geochronology of low-level sulfide minerals: applications and limitations

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Accurate and precise dating of ore-forming events is a fundamental, albeit problematical, aspect of successful ore deposit modelling. Historically, this task has been impeded by the lithophile character of parent elements of the long-lived decay systems routinely used for geochronology, coupled with a requirement to demonstrate contemporaneity of ore and dated silicate minerals.

The Re-Os system offers an alternative approach to dating mineralization events because Re is chalcophile. Although Re-Os molybdenite geochronology has emerged as a reliable chronometer of hydrothermal ore-forming events, the restricted paragenesis of molybdenite limits its overall utility. This limitation provided the impetus for Re-Os geochronology of sulfide minerals more commonly found in ore deposits. However, there exist major challenges with this methodology, most notably the inherently low Re concentrations characteristic of most common sulfide minerals and a current lack of understanding of the robustness of different sulfide minerals.

In order to assess the usefulness of common 'low-level' sulfides for Re-Os geochronology, we have systematically analyzed several different sulfide minerals that are common to a range of ore deposit types. Importantly, the sampled deposits comprise both hydrothermal and metamorphosed examples with well-constrained mineralization ages and P-T histories, thus allowing for the critical assesment of our determined Re-Os dates.

Our findings indicate that arsenopyrite and pyrite are extremely robust and reliable Re-Os chronometers of Paleoproterozoic to Mesozoic ore-forming events. Results from orogenic gold (e.g. Homestake, Meguma, Muruntau), sedimentary-hosted (e.g. Sherritt Gordon, Red Dog) and other deposit types are reviewed. However, despite the demonstrably accurate, high precision (generally ±1%; 2σ) ages obtained for these post-Archean deposits, pyrite and arsenopyrite from Archean examples typically yield less precise results, due primarily to low Re contents and sampling issues. We find that some other common sulfide minerals (e.g. pyrrhotite and spahlerite) are not suitable for Re-Os geochronology. This likely results from post-crystallization Re and/or Os diffusion, as corroborated by laboratory experiments on pyrrhotite.