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Twenty Years On – Re-Os Revolution for Crustal Rocks

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Re-Os (rhenium-osmium) isotope geochemistry is now accepted as a geologically robust method to address fundamental issues in Earth time using geologic media that were previously not datable. The Os isotope ratio ($^{187}Os/^{188}Os$) gives us a context to characterize basic earth reservoirs that sequester and subsequently release these two elements, Re and Os.

The first revolution was for those working in ore geology [1]. Previously, there was no way to directly date an ore deposit other than traditional methods aimed at so-called "gangue" minerals believed to be associated with ore deposition. Argon-based geochronology generally failed to capture primary ages for mineralization as multiple intrusive events or prolonged cooling toyed with the integrity of argon-based isotopic systems. The mineral molybdenite (MoS_2) began delivering essentially infallible Re-Os ages [2]. Sample acquisition in a geologic context became key in dating molybdenite. Other sulfides also began providing robust Re-Os ages, most notably pyrite and arsenopyrite. Uniquely, the Re-Os chronometer is sensitive to oxidation (i.e., chemical disturbance), but not temperature.

The second revolution came for those struggling to put time pins in stratigraphic units where fossils and ash beds are lacking. That is, Re-Os geochronology delivers where biostratigraphy and U-Pb dating cannot be used to bracket time. On the other hand, Re-Os dating can be used to attach absolute time to fossil horizons [3], or to evaluate the timing and duration of mass extinctions [4]. With Re-Os, extraction of organic matter representing the hydrogenous component of organic-rich sediments (e.g. black shales), readily yields both time pins and initial Os ratios that can be used to characterize marine and lacustrine settings at the time of sediment deposition.

The third revolution was for those working with petroleum systems. It was an obvious step to test the integrity of the Re-Os system when kerogen was called on to make bitumen and oil [5], or marine coal [6]. Isochronous Re-Os results fuel the still on-going debate of what processes are we dating with kerogen, bitumen, oil and oil components, and the relationship of those ages to diagenesis, and hydrocarbon maturation and migration.

In 20 years, Re-Os has become a highly sought after geochemical tool to determine the timing and duration of Earth-changing events, from Early Archean to present, and Os isotopic characterization of those events. Novel "within revolution" examples will be discussed (e.g., bracketing glacial events and metamorphic events using molybdenite, and dating organic material from black cherts).

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