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Graphite: A New Chapter in Re-Os Geochronology

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Earth's crustal Re-Os budget has conventionally been divided into three primary reservoirs (organic-rich sedimentary rocks, hydrocarbons, and sulfides) that collectively defined the field of crustal Re-Os geochronology. Recent research by Toma et al. (2022) has expanded this definition to include natural graphite, which previously had no geochronological potential. Instead, graphite-forming events were inferred from the age dating of adjacent host-rock materials (e.g. white mica Ar-Ar dating).

Here we discuss the state of the art of graphite Re-Os research. We begin by testing graphite Re abundances in relation to those found in the upper continental crustal (UCC), terrestrial sulfides, organic-rich sedimentary rocks, and hydrocarbons and show that graphite Re concentrations exceed UCC values but are comparable to other terrestrial reservoirs. This is followed with comparisons of the inter-group Re variations for graphites formed in metamorphic, hydrothermal, and meteoritic environments. Our findings indicate that Re contents trend highest in metamorphic graphite, followed by meteoritic, and then hydrothermal graphite.

Applications of graphite Re-Os dating are presented in the context of three (two published [1] and one unpublished) Re-Os graphite datasets. The first two samples comprise hydrothermal graphite formed in low-crustal shear zones (Wollaston-Mudjatik Transition [Gr_{WMT}], Canada]) and tanzanite-tsavorite gemstone deposits (Merelani Hills [Gr_{MH}] Tanzania), whereas the last sample consists of metamorphic graphite formed in the Franciscan subduction zone (Laytonville Quarry [Gr_{LQ}]; USA).

In all three cases, high-precision Re-Os graphite dates were obtained (Gr_{WMT} = 1731.52 ± 7.43; Gr_{MH} = 586.89 ± 2.39 [MSWD = 1.2]; Gr_{LQ} = 161 Ma]) that match the inferred formation ages of graphite mineralization in each locality determined by other radiometric methods or geological constraints. When coupled with SIMS C isotopes and Raman and XRD thermometry, Re-Os graphite dating is a powerful tool capable of expanding our understanding of ore genesis, graphitization, and carbon cycling in the crust-mantle system.

[1] Toma et al. (2022) *Geochimica et Cosmoschimica Acta*.