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From subduction zone metamorphism to element cycling: insights from graphite Re-Os dating

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Subduction is a fundamental driver of plate tectonics and trace element cycling in the Earth. Subduction of oceanic lithosphere, for example, is critical for transferring crustal material back into the mantle and/or fertilizing the continental lithosphere with slab-derived elements, such as carbon, that are important components of long-term element cycling. The Franciscan Accretionary Complex is one such (Jurassic aged) subduction zone that records Os isotope evidence of metasomatic, slab-derived, fluid interaction with arc-mantle that generated peridotites in the fore-arc[1].

Here we explore the possible mineralogical sources of radiogenic Os fertilization in the Franciscan forearc using graphite Re-Os dating of graphite-rich schists (Laytonville Quarry, California) once entrained in the subducted slab. A coupled graphite-pyrite Re-Os date yields a precise isochron age of 161± 1.66 Ma that overlaps with the early, eclogite-amphibolite, stages of subduction (170-160 Ma) and production of peridotitic melts (160-150 Ma) in the fore-arc. Raman spectroscopy of graphitic carbon delimits graphite crystallization temperatures to 461-506℃.

Graphites retain $^{187}Os/^{188}Os$ initial values (0.19) elevated above the $^{187}Os/^{188}Os$ values present in Franciscan fore-arc peridotites (0.13-0.16). However, prior modelling suggests that these peridotites inherited these crustal signatures via mantle melts ($^{187}Os/^{188}Os$ = 0.126) interacting with slab-derived fluids ($^{187}Os/^{188}Os$ = 0.2-0.3)[1]. Such fluids are consistent with derivation of radiogenic Os from Franciscan graphite subducted to depths of 80-100 km. From this evidence we conclude that graphite is an important, and currently overlooked, source of Re and Os released into the mantle wedge and that sedimentary organic carbon turned graphite may dominate the global ^{187}Os flux entering subduction zones annually.

[1] Snortum & Day (2020), *Chem. Geol. 550, 119723*.