Dating mantle peridotites: What do whole-rock and mineral Re-Os isotopic signatures tell us?

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The Re-Os isotopic system is the geochronometer of choice to date partial melting of mantle peridotites and constrain the evolution of Earth's dynamics from the mantle standpoint. Whole-rock (WR) peridotite Re-Os signatures are the core of such investigations, sometimes complemented by Re-Os analyses of base metal sulphides (BMS) and platinum group minerals (PGM), the main Re-Os hosts in peridotites.

BMS and PGM show complex $^{187}Os/^{188}Os$ and $^{187}Re/^{188}Os$ signatures, mainly reflecting the origin of the BMS± PGM, the nature of the metasomatic agents and the agent/rock ratio involved in the reaction. Peridotites typically plot within the $^{187}Os/^{188}Os$ and $^{187}Re/^{188}Os$ ranges of their BMS±PGM with the difference between the $^{187}Os/^{188}Os$ ratios of the least radiogenic BMS±PGM and their host peridotite increasing with peridotite fertility (e.g., WR Al_2O_3), reflecting the increasing contribution of metasomatic BMS±PGM to the WR Re-Os mass balance. This highlights that in metasomatised peridotites – the rule rather then the exception - BMS may provide a record of much older partial melting, pushing back the age of the lithospheric mantle stabilization.

Os isotope compositions of BMS±PGM within individual peridotites may define several ages clusters and provide a more accurate picture of the complex petrogenetic history of the lithospheric mantle. These BMS±PGM age clusters may match regional or local crustal ages, supporting the view that the mantle and its overlying crust may be genetically linked but also provide mirror records of their subsequent geological, petrological and chemical evolution. But evidences for crust-mantle decoupling are also clear from both the Re-Os isotopic signatures of BMS and /or of ultra-depleted peridotites. Although the BMS±PGM Re-Os model ages push back in time the stabilization of lithospheric mantle, the overall dichotomy between Archean cratonic and circum cratonic peridotites; and post-Archean non cratonic peridotites and tectonites is well preserved. This ability of BMS±PGM to preserve older ages than their host peridotite underscores their survival for billions of years without being reset or reequilibrated despite the complex petrogenetic history of their host peridotite. As such, they are the mantle equivalent to crustal zircons.