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The origin of platinum group minerals in serpentinites, and implications for highly siderophile element mobility and the Re–Os geochronometer

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The highly siderophile elements (HSEs), which include Re and Os, provide geochemical tracers and geochronometers that have been used to constrain the formation and evolution of Earth's crust and mantle. Rocks from the Earth's mantle on the surface of Earth are commonly serpentinized, but the effect of serpentinization on the distribution of HSEs is poorly understood, partly because a large proportion of the HSE budget is hosted by rare, micrometer- to sub-micrometer-scale grains of platinum group minerals (PGMs). These grains are difficult to find, characterise, and interpret. A range of micrometre- to nanometre-scale analytical techniques, including atom probe tomography (APT) were used to find and characterize complex PGMs hosted by partially serpentinized samples from Macquarie Island, Australia, and the Oman Ophiolite, Oman.

The data reveal an extraordinary level of complexity and have been used to derive insights into aspects of HSE deportment and mobility that include: (1) differential mobility of the HSEs from a range of polyphase alloy grains from Macquarie Island, which show limited mobility of the iridium-group platinum group elements relative to that of the palladium-group platinum group elements; (2) retention of mantle-like Os isotope ratios within a serpentinization-affected alloy grain, based on APT analysis (Tenuta et al., 2024); and (3) destabilisation of laurite during the earliest stages of serpentinization, based on cold-seal experiments at 200–300 degrees Centigrade and 50 MPa.

Compositions and textures of the alloy grains, phase diagram constraints, and the presence of OH-rich volumes that are interpreted as fluid inclusions (Evans et al., 2023), indicate that PGMs commonly form prior to serpentinization but are modified by serpentinizing fluids. Elements such as Os show limited mobility, but the minerals that host them open and close to element and isotopic exchange during serpentinization, such that whole-rock and grain-scale HSE patterns and ratios may be decoupled.

Reference

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Tenuta, S., Evans, K. A., et al. (2024). Nanoscale Os isotopic quantification of Wadi Tayin dunite platinum group minerals by atom probe tomography. *Lithos*, *488-489*, 107841. https://doi.org/https://doi.org/10.1016/j.lithos.2024.107841